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ABSTRACT

As a part of the REACH (Refrigeration, Electro-Mechanical, Air-Conditioning, Heating) electromechanical cluster, this student manual contains individualized instructional units in the area of air conditioning. The instructional units focus on air conditioning fundamentals, window air conditioning, system and installation, troubleshooting and servicing, and heat pumps. Each unit follows a typical format that includes a unit sheet, information sheets, assignment sheets, and job sheets. The unit sheet is designed to guide the learner through each task and is comprised of two main sections. The first lists all information needed to identify the task and the sequence in which activities are performed. The second section identifies each activity. (Related teacher's guides are available as CE 026 352, CE 026 354-355.) (LRA)

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REACH

AIR CONDITIONING UNITS

DEVELOPED UNDER CONTRACTUAL AGREEMENT

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OFFICE OF VOCATIONAL EDUCATION
GEORGIA DEPARTMENT OF EDUCATION
ATLANTA, GEORGIA 30334
CHARLES McDANIEL, STATE SUPERINTENDENT OF SCHOOLS

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OF

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ATHENS, GEORGIA 30602

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AIR CONDITIONING UNITS

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SYSTEMS AND INSTALLATION AC-13 - AC-16	JACK DYE, COOSA VALLEY TECH
TROUBLESHOOTING AND SERVICING AC-17 - AC-22	JOE GARRISON DEKALB TECH

ASSIGNMENT NO.	TEXT NO.	PAGES	STUDY ASSIGNMENT
AC-01a	1	315-317	Read "How Old is Air Conditioning?" and "Early Technical Developments."
AC-01b	1	328-334	
AC-02a	1	647-651	Read "Introduction", "Air Velocity", and "Types of Outlets."
AC-03a	1	367-376	Read section on Heat Load Factors.
AC-03b	1	380-387	Read section on Residential Load Calculation.
AC-03c	1	393-398	Read section concerning Factors Which Affect Heat Gain.
AC-03d	1	388-392 398-402	Read section on Heat Loss Calculation Procedure. Read section on Heat Gain Calculation Procedure.
AC-04a	1	611-614	Read sections on Resistance Pressures, Air Flow Measuring Instruments, and Air Friction Charts.
AC-04b	1	647-650	Read sections on Air Velocity and Types of Outlets; study illustrations.
AC-07a	1	546-550	Read section on Mechanical and Electronic Filtration.
AC-0			No Text Assignment.
AC 0			No Text Assignment.
AC-0			No Text Assignment.
AC-09a	1	112-113	Read "Triple Evacuation" and "Charging the System."
AC-10a	2	227-230	Read section 7-31 "Fan Motors" and 7-32 "Shaded Pole Motors", study schematic on p. 229.
AC-11a	6	114-115	Start at ...Now we are troubleshooting, end at last sentence of complete paragraph.
AC-11b	6	312-313	Study troubleshooting chart.

TEXT ASSIGNMENT SHEET

ASSIGNMENT NO.	TEXT NO.	PAGES	STUDY ASSIGNMENT
AC-12a	3	60-61	Read section 3.7 "Schematic Diagrams" and study drawings and symbols.
AC-13a	1 2	575 416	Read last two paragraphs and study figure 10-46. Study figure 12-62.
AC-14a	1	552-557	Read section on "Central System Cooling Units" and study illustrations.
AC-15a	1	560-568	Read and examine illustrations.
AC-16a	1	560-563	Read section on residential split systems, examine illustrations.
AC-17a	1	307-308	Read from "Compressors" to "Controls."
AC-18a	1	171-176	Read from "Motors" to "Electric Meters."
AC-19a	1	731-735	Read inspection procedures and study illustrations.
AC-20a	1	741-744	Read "Refrigerant Leaks" and "Troubleshooting Guide."
AC-21a			No Text Assignment.
AC-22a	1	302-305	Read the sections on troubleshooting "Condensers" and "Evaporators."

MAJOR BLOCK Air Conditioning **NAME** _____

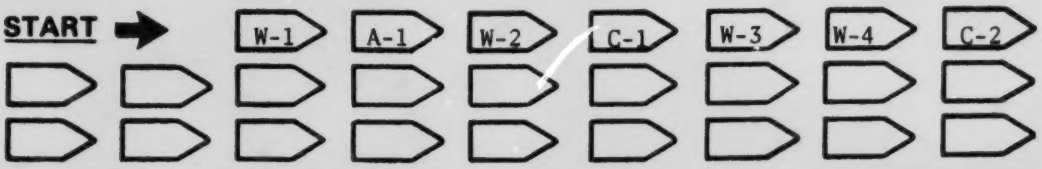
TASK Air Conditioning Fundamentals

UNIT Demonstrate a Knowledge of Air Conditioning Systems **TIME (est.)** _____ **(act.)** _____

UNIT NO. AC-01

OBJECTIVE(S)

Demonstrate a knowledge of human comfort control and identify the methods of air conditioning.



WRITTEN ASSIGNMENT(S)

W-1	Text Assignment AC-01a
W-2	Assignment Sheet AC-01a
W-3	Text Assignment AC-01b
W-4	Information Sheet AC-01a
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide/Tape AC-01a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	
L-2	
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

The different types of air conditioning systems have been shown on the audio-visual presentation describing the appearance and how it should function. With this knowledge we can now locate and visualize the actual systems in the lab area.

The window unit is a simple unit and can be installed, as a package, in a window opening or through the wall of a room. With the instructor's assistance, locate a window unit in the lab area. Please note and record the following:

1. Enclosure _____
2. Make, or brand name _____
3. BTU capacity _____
4. Type of compressor _____
5. Voltage _____
6. Ampere rating _____
7. Type of fan assembly _____
8. Type of filter _____
9. Size of filter _____
10. Observe the condenser _____
11. Observe the evaporator _____
12. Observe the metering device and record the type _____

    _____
13. Please note overall condition. good___fair___poor___
14. Reassemble all panels and screws.
15. Obtain instructor for information regarding the window unit, if needed.

The residential air conditioning system is widely used to cool the home during the hot summer months. These units are used in conjunction with the heating system. Whereas, heat can be available during the cold winter months. Most of the heating and air conditioning systems are forced air by using a duct system that supplies conditioned air to each room of the house.

In order to get familiar with the different types of residential (remote) air conditioning systems, it is best to observe several condensing units in the lab area. While observing the units note and record the following data from one condensing unit:

1. Location of the condensing unit_____
2. Model number of the condensing unit_____
3. Voltage_____
4. Phase_____
5. Ampere FLA_____ LRA_____
6. Model number of the compressor_____
7. Type of compressor_____
8. Brand name of the compressor_____
9. Brand name of the condensing unit _____
10. Type of condenser fan motor_____
11. Type of condenser, air _____ water _____
12. Direction of air flow across the condenser _____
13. Tonnage, or BTU capacity of the condensing unit per hour_____
14. Type of refrigerant_____
15. Condition of the condensing unit_____
16. Obtain instructor for assistance, if needed

The other half of the remote air conditioning system is the inside unit. This unit consists of the evaporator coil for cooling and the heating compartment which is used for heating. Also, there is a blower assembly that transfers air through the duct system and a filter for cleaning the air. Observe several inside units from the laboratory area to distinguish a difference between brand names and design. From one inside unit, note and record the following data:

1. Name of manufacturer_____
2. Model No. _____
3. Voltage_____
4. BTU's, Input_____output_____
5. Type of blower assembly_____
6. Type of fan motor_____
7. Voltage of fan motor_____
8. Type of furnace, horizontal_____vertical_____
9. Fan motor FLA_____LRA_____
10. Type of evaporator coil_____
11. Type of drainage_____
12. Condition of inside unit_____

The package heating and air conditioning system is manufactured into one unit. All the system components are assembled within one enclosure. This system is installed directly near the outside wall in a location that would assure peak performance during operation. The discharge and return duct extends through the building wall and into the duct system. However if the package system is roof mounted the duct system extends through the roof. These systems are very efficient and certainly has its place to be installed.

Observe at least one package heating and air conditioning system from the lab area and record the following data:

1. Brand name_____
2. Voltage (air conditioning system) _____
3. Total amperes _____
4. Voltage (heating system)_____
5. Total amperes_____
6. Model No. _____
7. BTU capacity (air conditioning)_____
8. BTU capacity (heating)_____
9. BTU input_____output_____heating
10. Condition of package unit_____

The absorption system may be less popular than the air cooled compression type air conditioner. However, the absorption system is very efficient. The absorption system consists of a generator, condenser, evaporator and the absorber.

The principle of the absorption system is to cool the circulating water from the conditioned space. Unlike the compression system, the generator of the absorption system is heated by a gas flame. Hopefully, the generator can be heated by solar hot water. Observe the laboratory area for an absorption system and note the following components:

1. generator
2. condenser
3. evaporator
4. absorber
5. pump

The Hydronic chilled water air conditioning system is very common in the residential and commercial applications. The direct expansion evaporator chills the water which is circulated, by the use of a water pump, into an indirect evaporator coil which is within the space to be cooled. These systems are very efficient in every respect. With proper controls, zoned cooling can be helpful to save operating cost. A boiler system can be installed in conjunction with the cooling system to provide heat. Observe one hydronic system in the laboratory area and record the following data:

1. Name of condensing unit_____
2. Voltage_____
3. Ampere, FLA_____
4. Model No._____BTU capacity_____
5. Chiller assembly_____
6. Water pump
   1. Model No. _____
   2. Voltage_____
   3. Ampere, FLA_____
7. Expansion tank location_____
8. Indirect cooling coil location_____
9. Boiler Name_____
10. Boiler Model No._____

11. BTU input_____

12. BTU output_____

13. Note piping hook up of complete system.

The Solar System will become more popular in the future years. As we know the solar system now it will probably be obsolete in a few years. The basic system consist of solar panels or collectors, storage tanks, pumps control panel and heating coils. For cooling, a heat pump can be connected in conjunction with the solar system. Also, the heat pump can supply auxiliary heat upon demand.

As previously stated, the solar system can supply hot water to run the absorption system which may be used for cooling.

Observe one solar system from the laboratory area and note the following:

(If available)

1. Solar collectors
2. Storage tanks
3. Pumps
4. Control panel
5. Piping hook up
6. Auxiliary heat, if applicable
7. Cooling system hook up, if applicable
8. General overall installation

First, it is best to understand some of the principles of the human body and how various conditions effect the body that surrounds it.

Let's start, by saying the normal body temperature is 98.6 degrees F. This temperature is sometimes called subsurface or deep tissue temperature. An understanding of the way the body maintains this temperature helps in understanding the way the air conditioning process helps keep the body comfortable.

For body comfort, all of the heat produced must be given off by the body. Since the body produces more heat than it needs, heat must be constantly given off or removed.

The constant removal of body heat takes place through three natural processes which usually occur at the same time. There processes are:

1. Convection - heat flows from the body to the air surrounding the body which is cooler. As the warm air from the body moves upward, or through the return ducts, more cool air takes its place.

2. Radiation - is the process by which heat moves from a heat source (such as the sun or fire) to an object by means of heat rays. As the heat from the sun and the fire moves by radiation to a colder surface, the heat from the body moves to a colder surface.

3. Evaporation - is the process by which moisture becomes vapor. As moisture evaporates from a warm surface, heat is removed and the surface is cooled. For example, as moisture is given off through the pores of the skin and evaporates, heat is removed from the body.

Body comfort can be effected in several ways. The basic conditions are:

1. Temperature - comfort range or degree
2. Humidity - percent of moisture content
3. Cleanliness - pure air
4. Distribution - rate of speed

An illustration will better show the basic conditions.

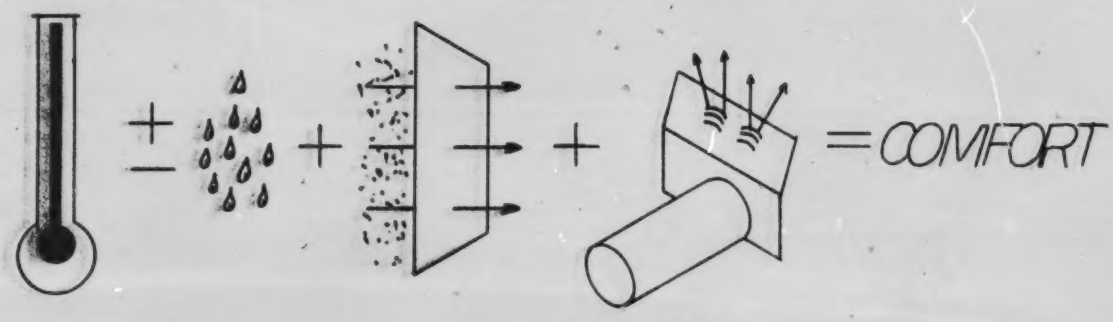


FIGURE A

The air conditioning system must be designed to control the temperature and humidity. Also, the system must clean and distribute the air. With an automatic control system these factors can be controlled during system operation.

Human body comfort may be defined as the physical sensation of warmth or coolness to the body. Therefore, certain conditions must be controlled by the air conditioning system during the hot summer months and a table of comfort zones if given for the winter months and summer months.

Tables of Comfort Zones

Winter

10%	relative humdidity and	78°F
20%	"	76°F
30%	"	75°F
40%	"	74°F
50%	"	73°F
60%	"	72°F
70%	"	71°F
80%	"	70°F

Summer

70%	relative humidity and	74°
60%	"	75°
50%	"	77°
40%	"	78°
30%	"	79°
25%	"	80°

These figures will give an indication of the relationship between temperature and humidity to achieve total comfort for the individual.

The above table may not be correct in every respect and may vary in degrees and percent. However, it does give a clear view of the rise and fall of degree and percent differences between summer and winter. Air movement is determined by the conditions and the space to be cooled. Excessive air motion in a room creates a cold draft, while less air motion may cause stale areas. Usually 15 to 25 feet per minute would be acceptable in most areas to feel comfortable.

Air conditioning may contribute to better health as a result of controlling air temperature, humidity, cleanliness, ventilation, and motion. Some of the benefits that are achieved as a result of good air conditioning are,

1. help to prevent heat rash
2. help people with heart ailments

3. relieve suffering of asthmatic and allergic patients.
4. relieve hay fever patients.
5. relieve patients with lung and repiratory ailments.
6. may help to protect health.

Air conditioning, as we know it today, may not continue to where a person can go into a building and always feel comfortable. It has been proven that air conditioning helps to increase production and quality work in industry. It increases the learning abilities of students in all levels of education. In space travel, air conditioning is vital to human survival. Air conditioning is here to stay in every respect. In our modern age we cannot do without it.

MAJOR BLOCK Air Conditioning **NAME** _____

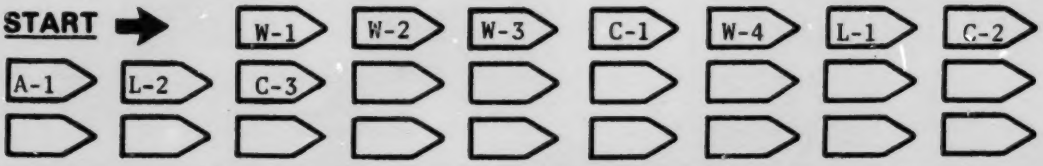
TASK Air Conditioning Fundamentals

UNIT Applying Basic Air Principles **TIME (est.)** _____ **(act.)** _____

UNIT NO. AC-02

OBJECTIVE(S)

Determine air properties through use of graphs and psychometrics.



WRITTEN ASSIGNMENT(S)

W-1	Text Assignment AC-02a
W-2	Information Sheet AC-02a
W-3	Information Sheet AC-02b
W-4	Assignment Sheet AC-02a
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set AC-02a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet AC-02a
L-2	Job Sheet AC-02b
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	
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Principles of Psychrometics

WET BULB is the temperature of air as read on a thermometer whose bulb is covered by a wetted wick and exposed to a rapidly moving stream of air. The thermometer has a wet boot on the end.

DRY BULB is the temperature of air as read on a thermometer whose bulb is in direct contact with the air. The measured temperature is known as sensible heat.

RELATIVE HUMIDITY is the amount of water content in the air as compared to the amount that would be contained in saturated air at the same dry bulb temperature. Relative humidity is the percent of moisture content in the air as compared to the total amount of moisture that could be in the air under certain conditions and temperature.

DEW POINT is the temperature to which air must be reduced to produce condensation of the moisture contained therin. Dew point is the saturation point on the psychrometic chart.

GRAINS OF MOISTURE is the unit of measurement of the amount of moisture in the air. One pound of water contains 7,000 grains of water vapor.

Read Psychrometic Charts

The psychrometic chart can be pictured as a shoe as illustrated in Figure A.

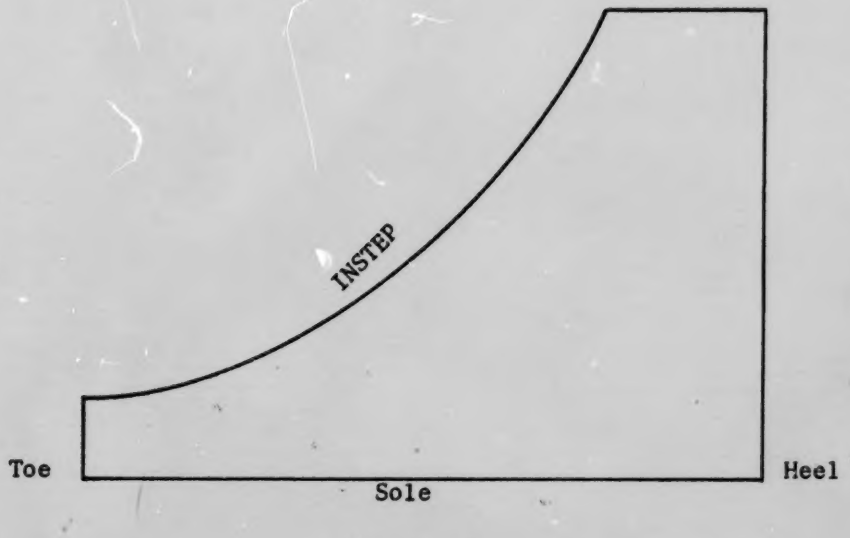


FIGURE A

Identification of the scales on the psychrometic chart will now be illustrated. The DRY BULB lines are perpendicular to the bottom line. See Figure B.
NOTE: Drawings are not to scale. Illustrations only.

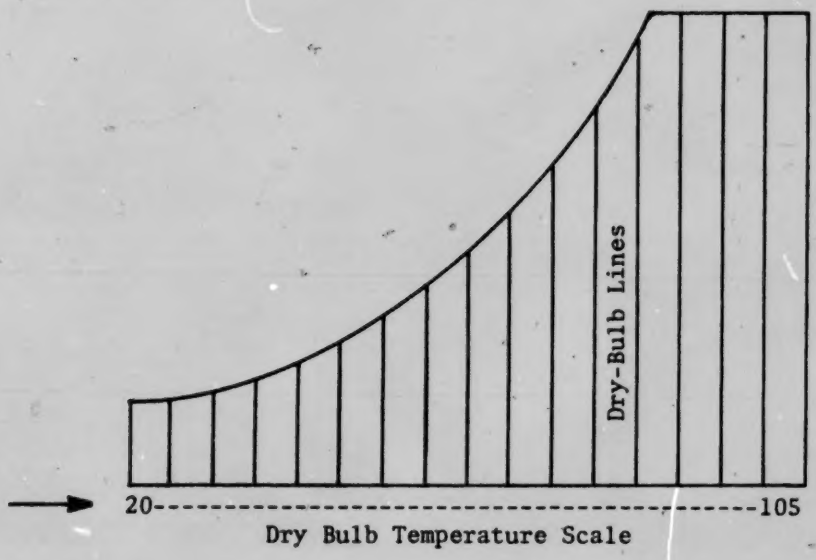


FIGURE B

The WET BULB lines are slanted from right to left or left to right. See Figure C.

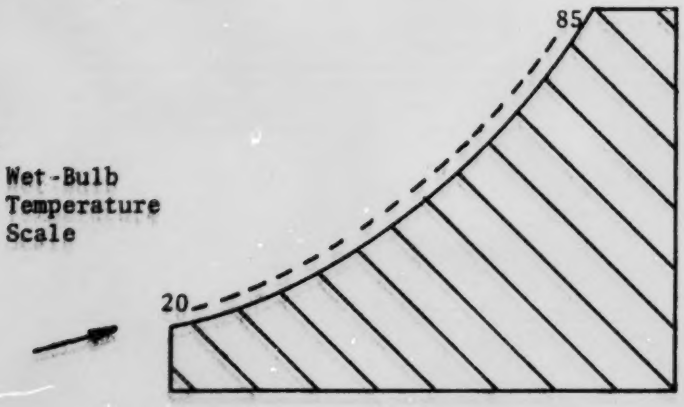


FIGURE C

The RELATIVE HUMIDITY lines are curved as illustrated in Figure D.

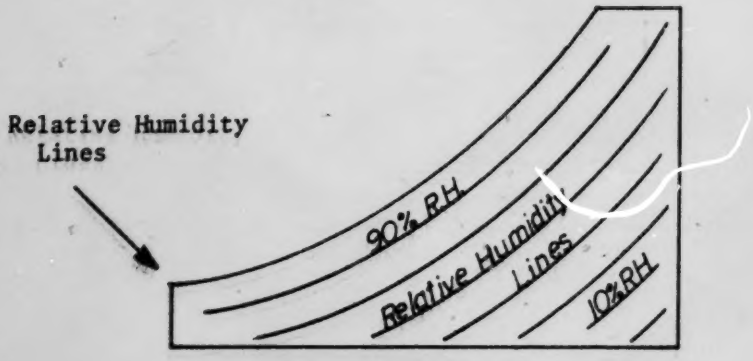


FIGURE D

The DEWPOINT lines are horizontal as illustrated in Figure E.

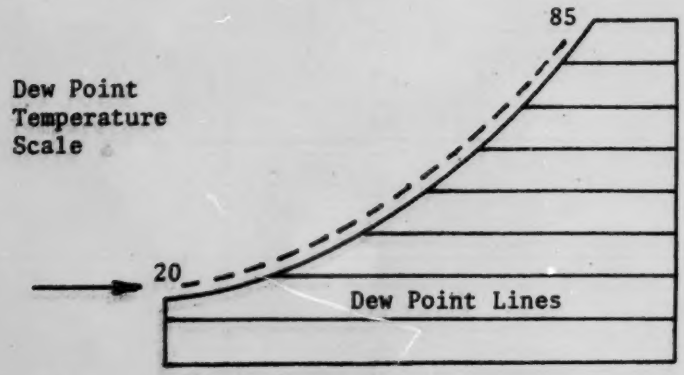


FIGURE E

The GRAINS OF MOISTURE lines are also horizontal as illustrated in Figure F.

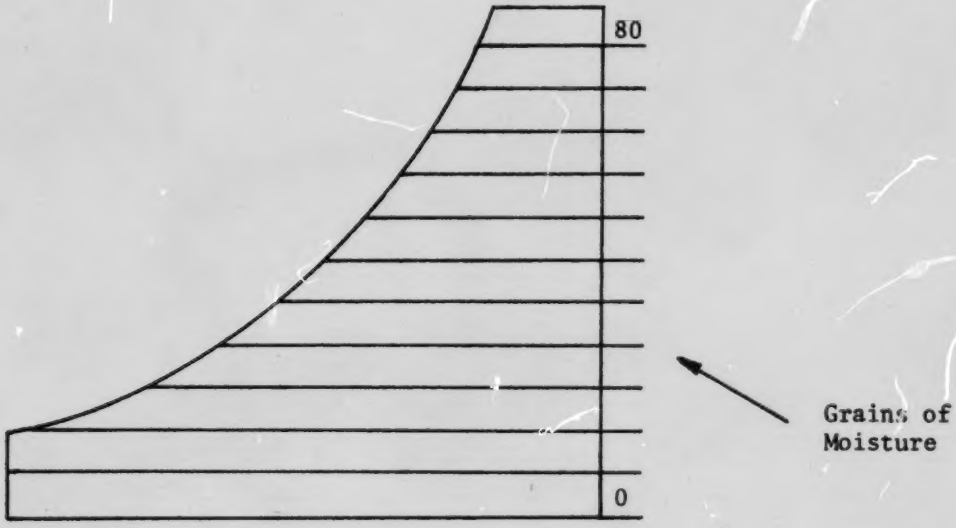


FIGURE F

The preceding drawings should illustrate the position and angle of lines for the properties that may be located on the psychrometic chart provided two values are known. Listed below are several combinations of known values in order to find the unknown value on the chart.

1. IF the dry-bulb and wet-bulb temperatures are known, the relative humidity can be read from the chart.

2. IF the dry-bulb temperature and the relative humidity are known, the wet-bulb temperature can be determined.

3. IF the wet-bulb temperature and the relative humidity are known, the dry-bulb temperature can be found.

4. IF the wet-bulb and dry-bulb temperatures are known, the dewpoint can be found.

5. IF the wet-bulb temperature and the relative humidity are known, the dewpoint can be read from the chart.

6. IF the dry-bulb temperature and the relative humidity are known, the dewpoint can be found.

The grains of moisture in the air can be determined if any of the following combinations of readings are known:

Dry-bulb temperature and relative humidity (RH)

Dry-bulb temperature and dewpoint

Wet-bulb temperature and relative humidity

Wet-bulb temperature and dewpoint

Dry-bulb and wet-bulb temperatures

Dew-point alone

The following assignment sheet will illustrate the various lines within the chart and how to locate a point or an unknown value by knowing two known values.

Locating Properties on Scale

The assignment sheet will prepare the learner to locate the unknown properties on the psychrometic chart. As a starting point, an example problem will be given listing two known values and solving for the third value. See Figures G-J.

Example Problem: Given 78° DB and 65° WB, find: RH. Answer: 50°

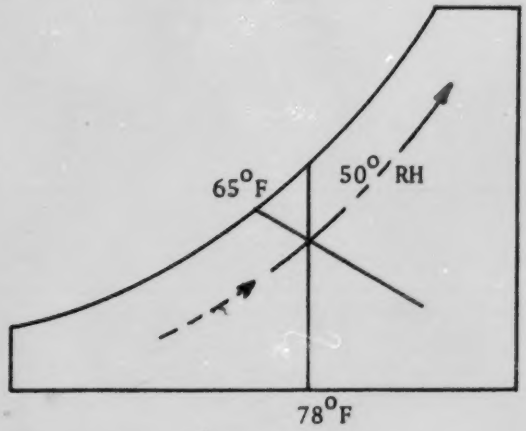


FIGURE G

Example Problem: Given 78° DB and 50° RH, find: WB Temperature. Answer: 65°

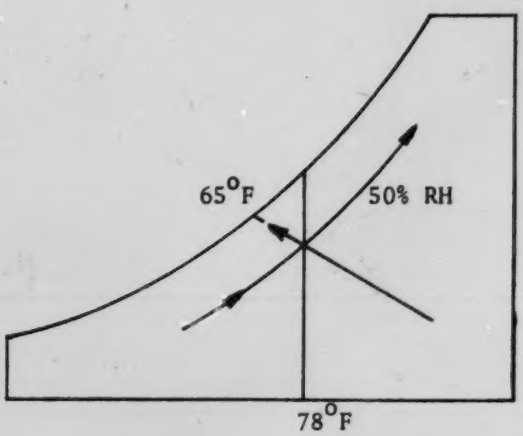


FIGURE H

Example Problem: Given 65° WB and 50% RH, find DB Temperature. Answer: 78° F

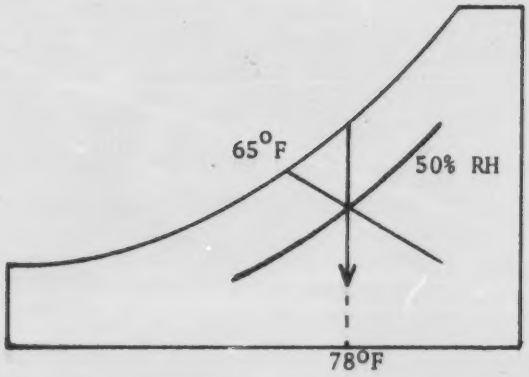


FIGURE I

Example Problem: Given 78° DB and 65° WB, find Dewpoint. Answer: 58° F

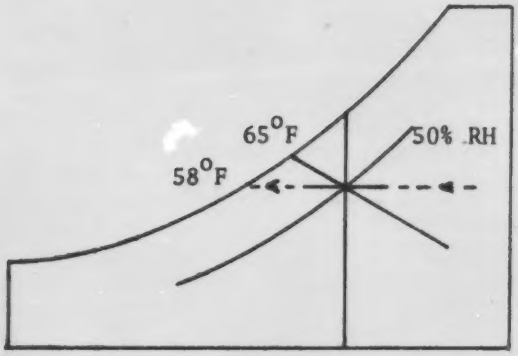


FIGURE J

Example Problem: Given 78° and 65° WB, find Grains of Moisture. Answer: 72

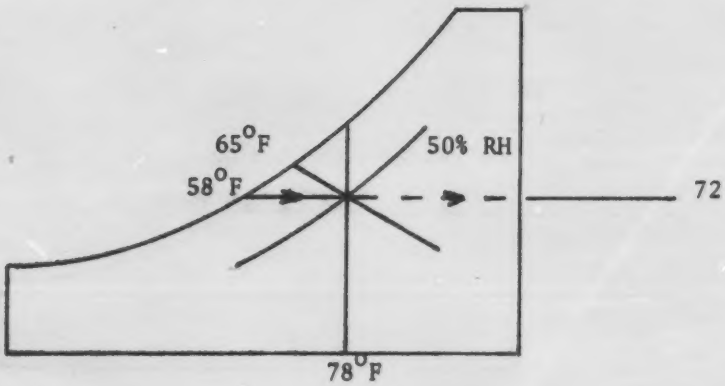


FIGURE K

The assignment sheet has given illustrations on how to plot an unknown value on the chart where two properties are given. Certainly, there are many other plots that can be made on the chart other than the five shown. However, this should give the learner a basic understanding of how to arrive at an answer on the chart by following a few basic rules.

Solve problems from chart. The student may obtain the paper (one time use) psychrometic charts, or preferably the reusable plastic type. The standard carrier psychrometric charts may be most useful. To solve the problems below, the student will plot the known properties on the chart in order to locate and record the unknown property.

Problem No. 1 - Find the Relative Humidity.

	DB	WB	RH
a	60°F	50°F	
b	70°F	60°F	
c	79°F	69°F	
d	79°F	70.5°F	
e	80°F	56.5°F	

FIGURE L

Problem No. 2 - Find the Wet Bulb Temperature.

	DB	RH	WB
a	72°F	34%	
b	78°F	96%	
c	79°F	62%	
d	70°F	9%	
e	66°F	40%	

FIGURE M

Problem No. 3 - Find Dry Bulb Temperature.

	WB	RH	DB
a	70°F	80%	
b	40°F	10%	
c	75°F	50%	
d	30°F	20%	
e	62°F	65%	

FIGURE N

Problem No. 4 - Find the Dewpoint.

	DB	WB	DP
a	70°F	61°F	
b	90°F	81°F	
c	55°F	50°F	
d	101°F	62°F	
e	80°F	71°F	

FIGURE O

Problem No. 5 - Find the Grains of Moisture.

	DB	WB	GR./LB.
a	80°F	65°F	
b	70°F	61°F	
c	101°F	62°F	
d	60°F	60°F	
e	45°F	40°F	

FIGURE P

Problem No. 6 - Find the missing values.

	DB	WB	RH	DP	GR./LB.
a	72°F				59 GR.
b		61°F	45%		
c	85°F		60%		
d	68°F			24°F	
e		71°F			63 GR.
f			12%		10 GR.
g			90%	68°F	
h	98°F				180 GR.
i	83°F	53°F			
			30%		10 GR.

FIGURE Q

Before leaving the psychrometics, one more problem should be plotted. This problem will deal with outside dry-bulb temperature and outside relative humidity.

Problem No. 7 -

Given: outdoor dry-bulb temperature - 85°F and
outdoor relative humidity - 70%

These conditions would not be comfortable to the average human being. However, the air conditioning system can correct these conditions by lowering the dry-bulb temperature and the relative humidity to a comfort zone. Now plot the known values on the chart (85° and 70%). Please use the following illustration as a guide line only.

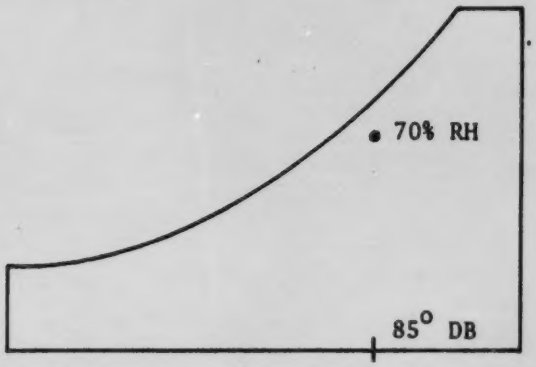


FIGURE R

Based on the comfort zone for cooling approximate 45 to 50% RH and 75 to 78° will suffice for the average person. The next plot on the chart will show 50% RH and 75°F.

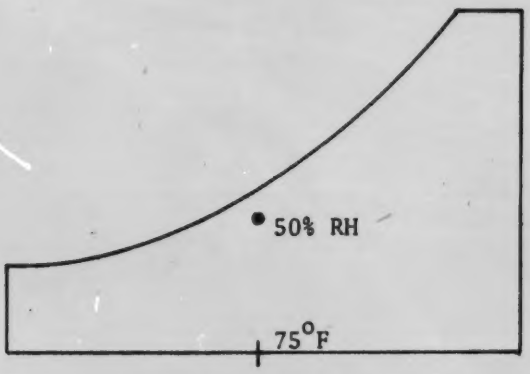


FIGURE S

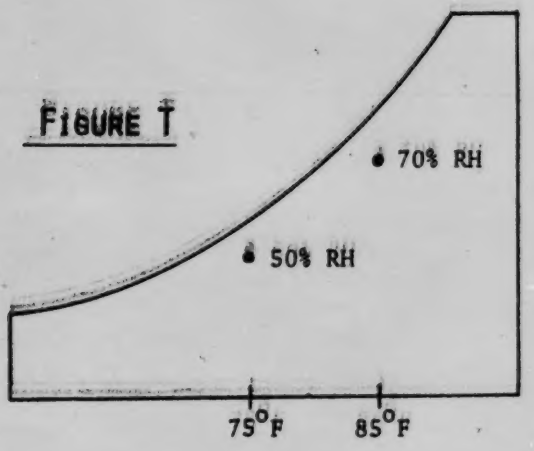


FIGURE T

The next step is to draw a line from 70% RH to 50% RH.

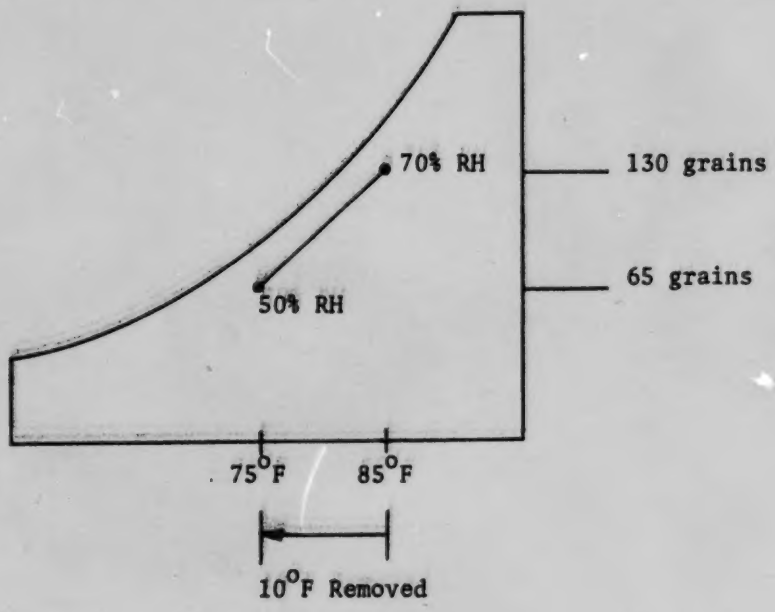


FIGURE U

As illustrated, the cooling system has removed 65 grains of moisture and the temperature (DB) has been reduced 10^{o} to 75^{o} F. Our condition in the room is now 50% RH and 75^{o} F. which is a comfortable range.

More advanced plots can be made on the psychrometic to arrive at certain conditions.

Use Psychrometer and Determine Readings from Chart:

I. Obtain a sling psychrometer for the purpose of reading the wet and dry bulb temperatures from the different areas surrounding the school. A suggested guide line below may be helpful for the learner.

1. To find the relative humidity (RH) from the outside.

   a. Use the sling psychrometer and record the wet and dry bulb temperatures. DRY BULB _____ WET BULB _____.

   b. Plot the two readings on the psychrometic chart.

   c. Find the relative humidity. Humidity _____%.

2. To find the relative humidity (RH) from a class room .

   a. Use the sling psychrometer and record the wet and dry bulb temperatures. DRY BULB _____ WET BULB _____.

   b. Plot the two readings on the psychrometic chart.

   c. Find the relative humidity. Humidity _____%.

3. To find the relative humidity (RH) from the lab area.

   a. Use the sling psychrometer and record the wet and dry bulb temperatures. DRY BULB _____ WET BULB _____.

   b. Plot the two readings and the psychrometic chart.

   c. Find the relative humidity. Humidity _____%.

4. The instructor may have the option to assign additional problems to the learner that may be plotted on the chart.

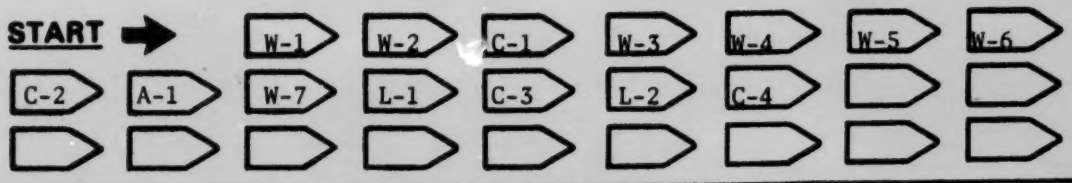
MAJOR BLOCK Air Conditioning **NAME** _____

TASK Air Conditioning Fundamentals

UNIT Calculating Heat Loads **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-03

OBJECTIVE(S)



WRITTEN ASSIGNMENT(S)

W-1	Text Assignment AC-03a
W-2	Assignment Sheet AC-03a
W-3	Text Assignment AC-03b
W-4	Assignment Sheet AC-03b
W-5	Text Assignment AC-03c
W-6	Assignment Sheet AC-03c
W-7	Text Assignment AC-03d

AUDIOVISUAL(S)

A-1	Slide Set AC-03d
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet AC-03a
L-2	Job Sheet AC-03b
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	Instructor Check
C-5	
C-6	
C-7	
C-8	
C-9	

Match the following statements and factors:

_____1.	Heat flow resistance	a. sensible gain
_____2.	An internal heat load can be caused by people, lights, and _____.	b. shading
_____3.	Bulk insulation used in houses.	c. shading
_____4.	A method used in reducing summer cooling needs.	d. appliances
_____5.	An air conditioning load factor.	e. & f. R value
_____6.	Heat passing through the ceiling.	g. Batts
_____7.	Reduces heat gain from the sun.	h. ventilation
_____8.	The thicker the insulation, the higher the _____.	

In the chart below, list factors affecting the heat loss of your classroom:

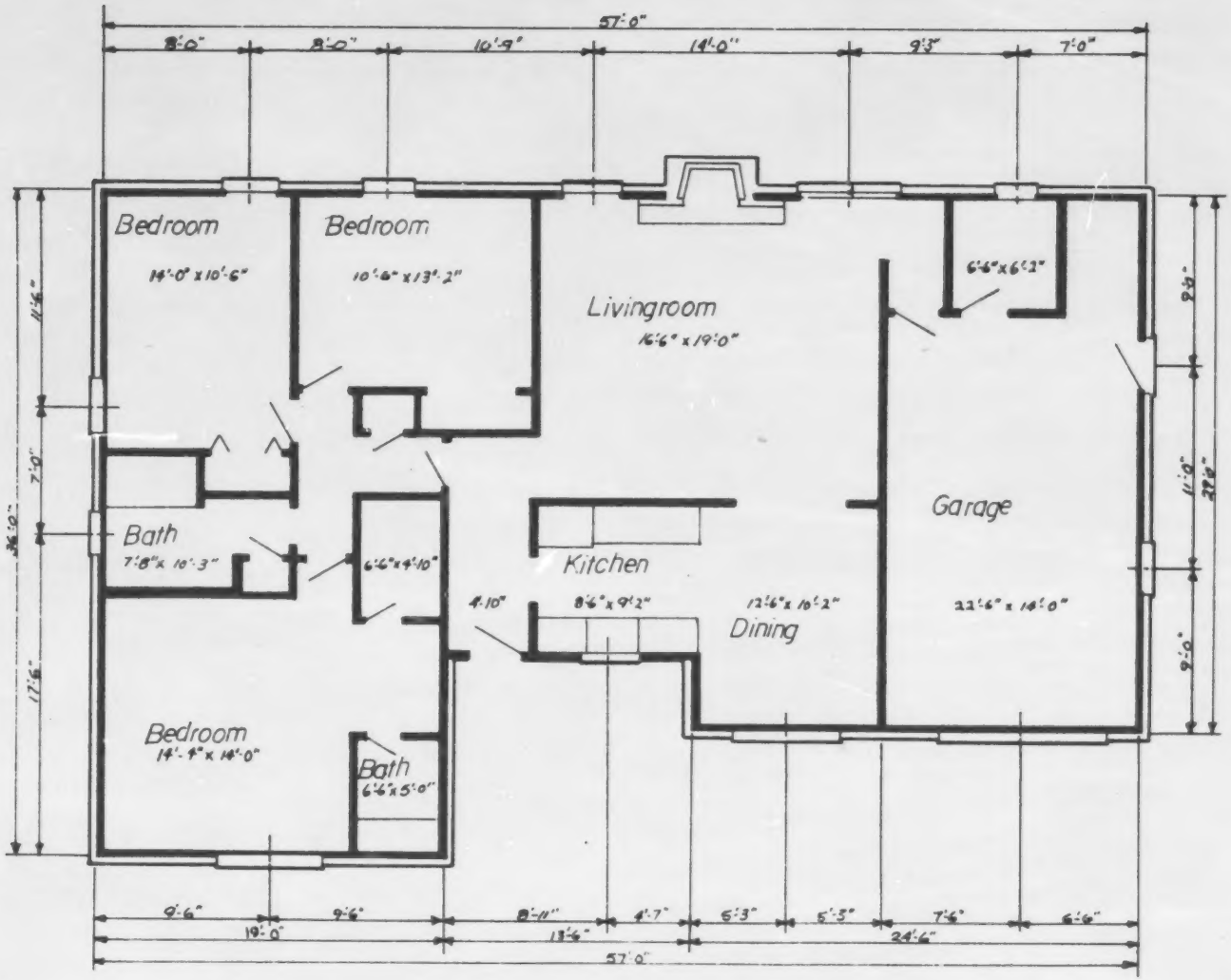
Chart 1

Type of Loss	Area

In the chart below, list factors affecting the heat gain of your classroom.

Chart 2

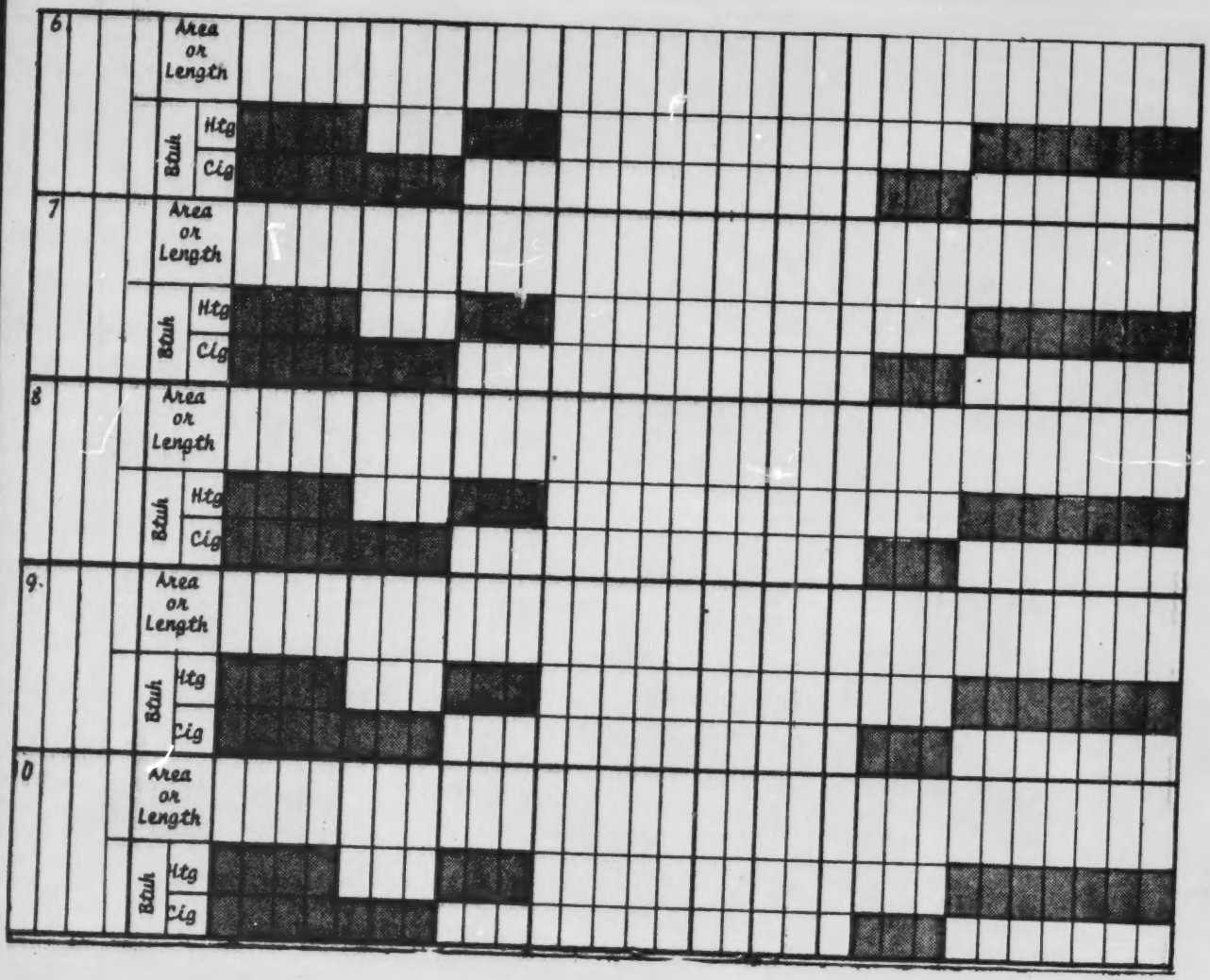
Type of Gain	Area



PLAN ONE
(to be used with job sheet AC-03a and AC-03b)

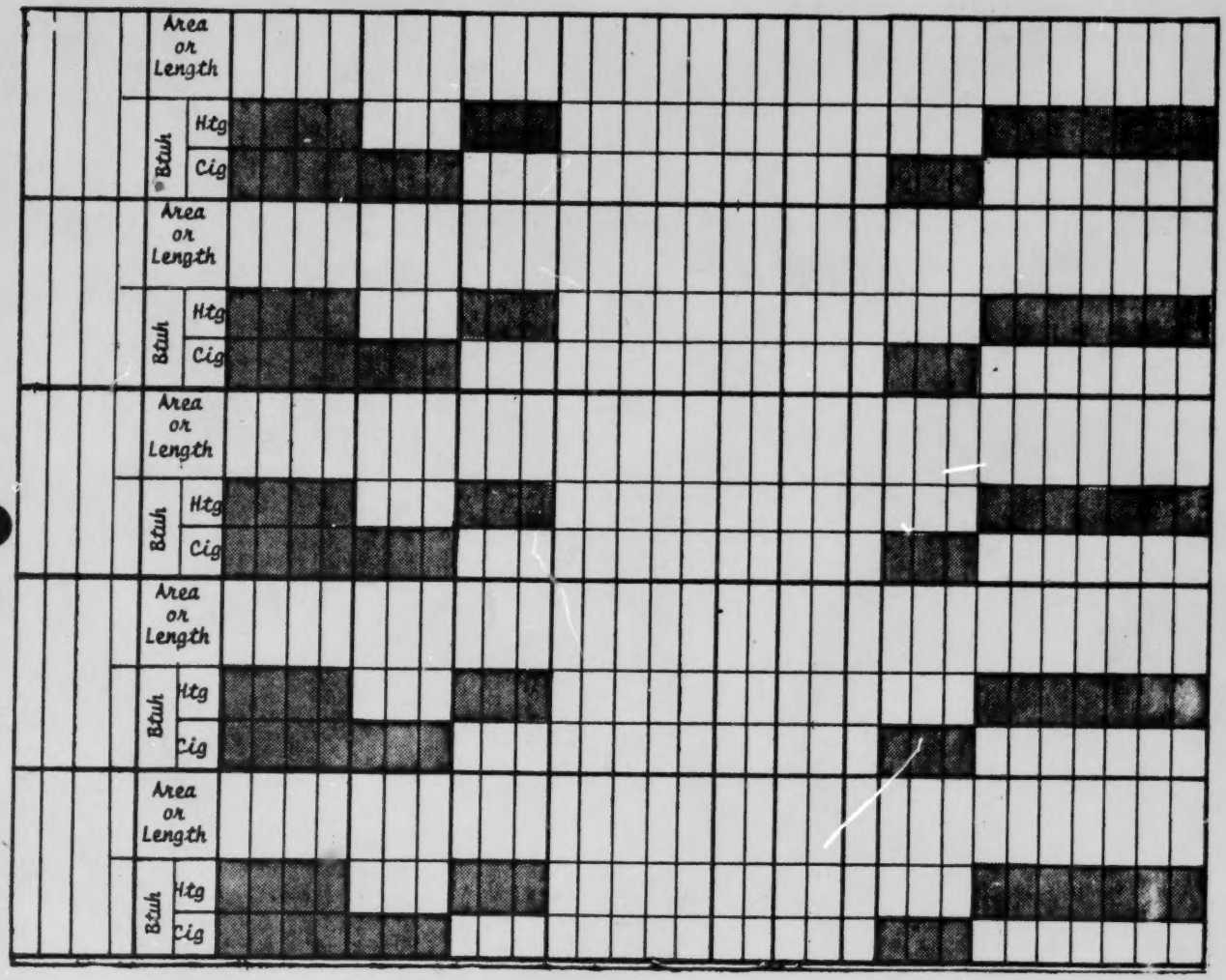
Using the plans and forms provided and the manual J tables from your text, complete a heat gain calculator for the house in plan 1.

		Entire House	1.	2.	3.	4.	5.
1.	Name of Room						
2.	Room Dimensions, Feet						
3.	Exposed Wall Expressed in Running Feet						
4.	Ceiling HT, FT Directions Room Faces						
	TYPE OF EXPOSURE	Btuh Htg / Btuh Clg / Const. No. / Area or Length	Btuh Htg / Btuh Clg / Area or Length	Btuh Htg / Btuh Clg / Area or Length	Btuh Htg / Btuh Clg / Area or Length	Btuh Htg / Btuh Clg / Area or Length	Btuh Htg / Btuh Clg / Area or Length
5. a. b. c. d.	Total Exposed Partitions and Walls						
6. a. b. c.	Windows and Sliding Glass Doors (heating)						
7.	Windows and Sliding Glass Doors (heating) — North						
	NE & NW or E & W						
	SE & SW or South						
8.	Other Doors						
9. a. b. c. d.	Total, Net Exposed Partitions and Walls						
10. a. b.	Ceilings Area						
11. a. b.	Floor Areas						
12.	Ventilation						
13.	Sub Total Heat Loss (Btuh)						
14.	Duct Heat Loss (Btuh)						
15.	Total Heat Loss (Btuh)						
16.	Btuh Heat Loss @ 300 Per Person						
16a.	Total 1200 Btuh for Appliances						
17.	Total Sensible Heat Gain (Btuh)						
18.	Total Duct Gain Btuh						
19.	Total of Lines 17 and 18 (Cooling)						
20.	Heat Gain (line 19 x 1.3)						
21.	Btuh for Air Quantities						


6
Area or Length
Btuh
Htg
Clg
7
Area or Length
Btuh
Htg
Clg
8
Area or Length
Btuh
Htg
Clg
9
Area or Length
Btuh
Htg
Clg
10
Area or Length
Btuh
Htg
Clg

Using the plans and forms provided and the manual J tables from your text, complete a heat loss calculation for the house in plan 1.

		Entire House	1.	2.	3.	4.	5.
1.	Name of Room						
2.	Room Dimensions, Feet						
3.	Exposed Wall Expressed in Running Feet						
4.	Ceiling HT, FT Directions Room Faces						
	HTM Btuh Clg						
	HTM Btuh Htg						
	Const. No.						
	TYPE OF EXPOSURE	Btuh Clg / Htg / Area or Length	Btuh Clg / Htg / Area or Length	Btuh Clg / Htg / Area or Length	Btuh Clg / Htg / Area or Length	Btuh Clg / Htg / Area or Length	Btuh Clg / Htg / Area or Length
5.	a. Total Exposed Partitions and Walls						
	b. Total Exposed Partitions and Walls						
	c. Total Exposed Partitions and Walls						
	d. Total Exposed Partitions and Walls						
6.	a. Windows and Sliding Glass Doors (heating)						
	b. Windows and Sliding Glass Doors (heating)						
	c. Windows and Sliding Glass Doors (heating)						
7.	North Windows and Sliding Glass Doors (heating)						
	NE & NW or E & W Windows and Sliding Glass Doors (heating)						
	SE & SW or South Windows and Sliding Glass Doors (heating)						
8.	Other Doors						
9.	a. Total, Net Exposed Partitions and Walls						
	b. Total, Net Exposed Partitions and Walls						
	c. Total, Net Exposed Partitions and Walls						
	d. Total, Net Exposed Partitions and Walls						
10.	a. Ceilings Area						
	b. Ceilings Area						
11.	a. Floor Areas						
	b. Floor Areas						
12.	Ventilation						
13.	Sub Total Heat Loss (Btuh)						
14.	Duct Heat Loss (Btuh)						
15.	Total Heat Loss (Btuh)						
16.	Btuh Heat Loss @ 300 Per Person						
16a	Total 1200 Btuh for Appliances						
17.	Total Sensible Heat Gain (Btuh)						
18.	Total Duct Gain Btuh						
19.	Total of Lines 17 and 18 (Cooling)						
20.	Heat Gain (line 19 x 1.3)						
21.	Btuh for Air Quantities						


Area or Length
Btuh
Htg
Clg
Area or Length
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Area or Length
Btuh
Htg
Clg
Area or Length
Btuh
Htg
Clg

MAJOR BLOCK Air Conditioning **NAME** _____

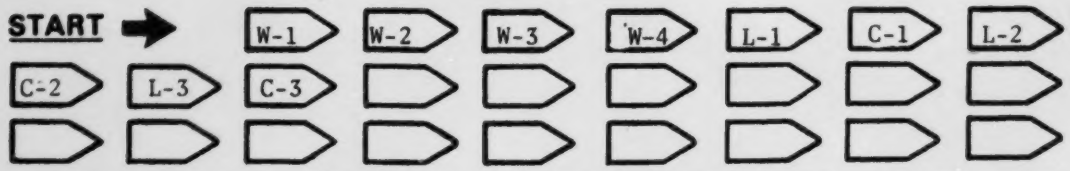
TASK Air Conditioning Fundamentals

UNIT Applying Principles of Air Movement **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-04

OBJECTIVE(S)

Apply principles of air movement through ductwork and air distribution inside the room.



WRITTEN ASSIGNMENT(S)

W-1 Text Assignment AC-04a
W-2 Information Sheet AC-04a
W-3 Text Assignment AC-04b
W-4 Information Sheet AC-04b
W-5 _____
W-6 _____
W-7 _____

AUDIOVISUAL(S)

A-1 _____
A-2 _____
A-3 _____
A-4 _____
A-5 _____
A-6 _____
A-7 _____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet AC-04a
L-2 Job Sheet AC-04b
L-3 Job Sheet AC-04c
L-4 _____
L-5 _____
L-6 _____
L-7 _____
L-8 _____
L-9 _____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 _____
C-5 _____
C-6 _____
C-7 _____
C-8 _____
C-9 _____

The function of a duct system is to transmit air from the air handling apparatus to the space to be conditioned.

To do this function in a practical manner a system must be designed within limits of available space, friction loss, velocity, sound level, heat and leakage loss and gains.

Air exerts pressure as can be seen when a balloon or tire is inflated. This same pressure is present in duct work and since it is not dependent upon air movement, it is called static (stationary) pressure. This kind of pressure pushes against the wall of the ducts.

Since pressures in a duct system are seldom very large the usual pressure measuring instruments cannot be used. Instead, sensitive gauges which measure the effect of air pressure on a column of water are used. This instrument is called a U-tube manometer. One leg of the instrument is connected to the air duct while the other is left open to the atmosphere. The greater pressure inside the duct forces the water down in one leg and up the other leg (Figure A).

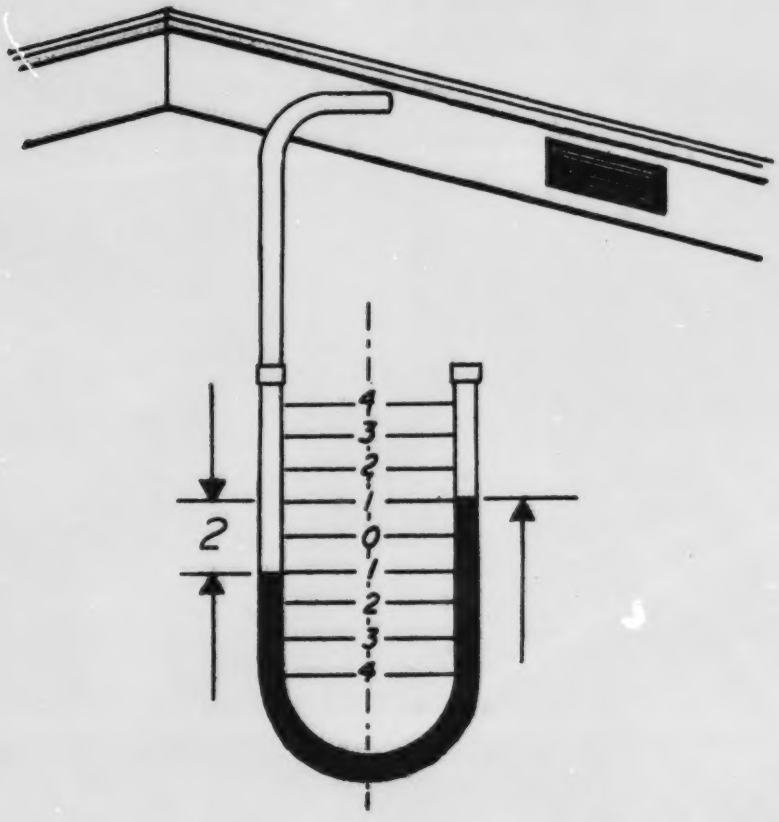


FIGURE A

When air is moving it creates greater pressure than when standing still. If the manometer leg were placed so that the flow of air through the duct were directly against the instrument, the pressure would be greater than the static pressure alone. This additional pressure is called velocity pressure and the total pressure is made up of both the static and velocity pressure.

Instead of measuring the static and velocity pressure directly, an instrument called the pitot tube measures the total pressure velocity. Pressure, then, is obtained by subtracting static from amount. (Figure B).

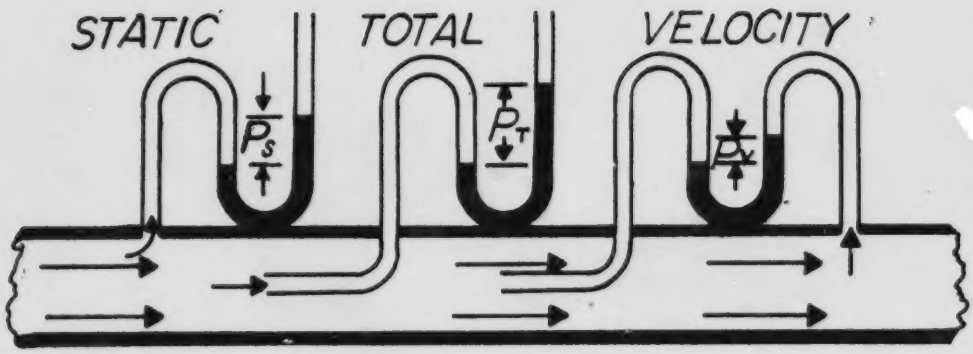


FIGURE B

The anemometer is an instrument designed originally for meteorological measurements, but is suitable for measuring velocities of air streams in large ducts or the face velocity of air entering or leaving registers, grillers, filters, or coils.

When the instrument is placed in an air stream, the wheel with the vanes rotates, and the revolutions are registered on a dial as the actual linear travel, in feet, of the air stream. A stop watch is used in conjunction with the anemometer. If the elapsed time is 1 minute, the reading on the anemometer dial will be the average velocity in feet per minute.

The cross-sectional area of the duct, or grille should be divided into a number of approximately equal areas. With a reading taken in the center of each of these areas, to determine an average of all the readings. (Figure C).

FIGURE C

Understanding Air Movement

Improper piping will often cause trouble in a refrigeration system. The same is true with the duct work of an air conditioning or heating system. The best equipment can fall short of its job requirements due to a poorly designed or an improperly constructed duct system.

Duct transformations are used to change the shape of a duct or to increase or decrease duct area. When the shape of a rectangular duct is changed but the cross-section remains the same, a slope of 1" to 7" (may also be expressed as 1" slope for each 7 linear inches or a 30° slope) is recommended for the sides of the transformation. If this slope cannot be maintained, a maximum slope of 1" to 4" (or 45°) should not be exceeded. If the 45° should become necessary it should be on the leaving side (Figure D).

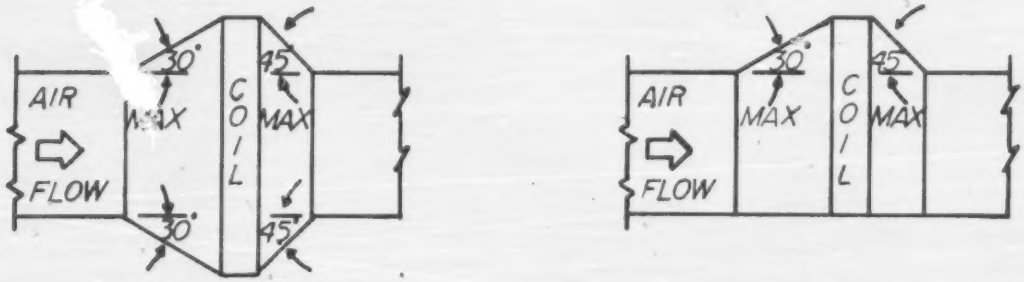


FIGURE D

Ducts are available in circular, rectangular or square shapes. Round ducts have an advantage because the round shape is more economical and will carry more air for a given size. This means the installer will need less duct material, less duct surface, less duct surface friction, and less insulation than for other shapes. For example a 12" diameter duct has the same carrying capacity as a 15 x 8 inch. The circumference of the round duct is 37.7 compared to the rectangular duct perimeter of 46". Therefore, the rectangular duct requires more metal to carry the same amount of air (Figure E).

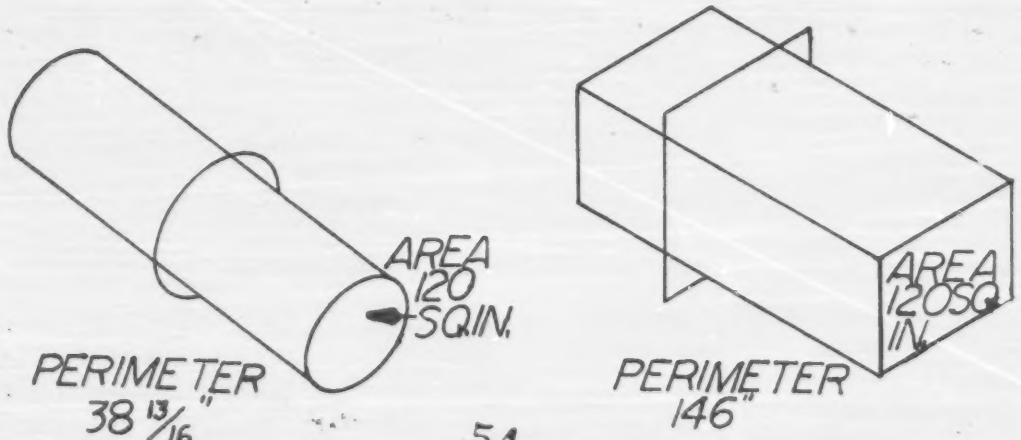


FIGURE E

From a practical point of view the rectangular duct may be preferred when space limitation requires that minimum duct height be used. If a 12" round duct was suspended from a basement ceiling the head room would not be as great as that obtained with a 15" wide by 8" deep duct. It is common practice to use rectangular ducts for main supply and round ducts for branch runs in a duct system (Figure F).

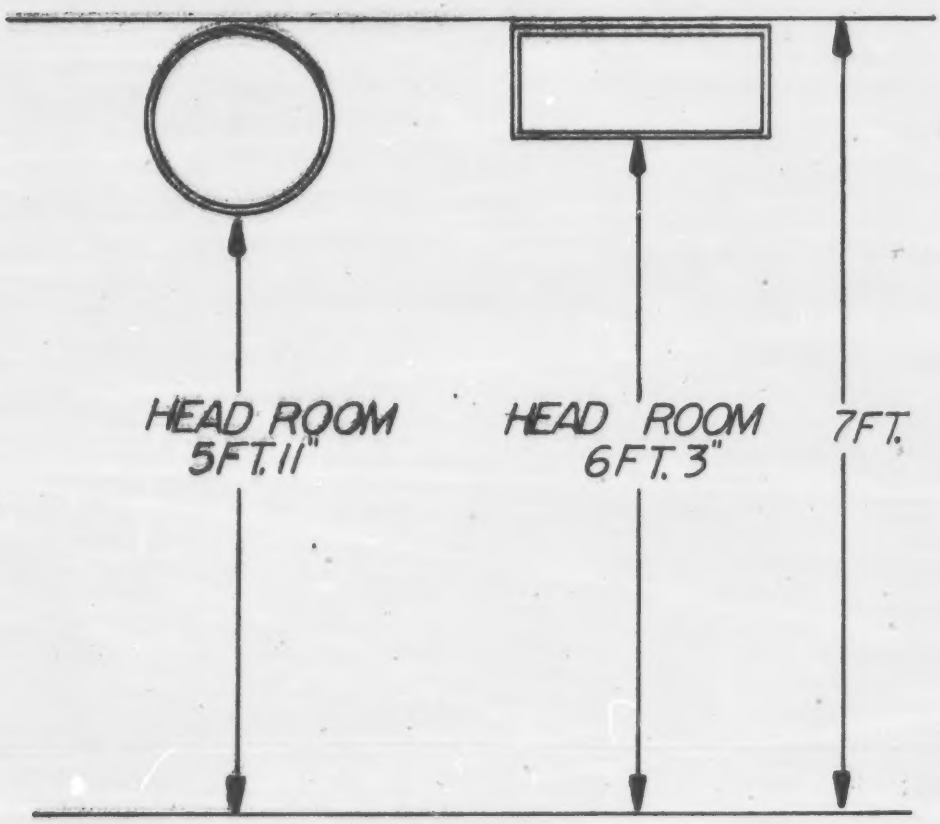


FIGURE F

Using a U-tube manometer take a static pressure reading at the outlet of the fan, on two branch ducts, and near the end of the main truck duct.

Using the same holes take a total pressure reading of the system with incline manometer. Take the reading with the filter in and with it out. Now block off 1/3 of the filter (this will simulate a dirty filter) and take readings.

Use an anemometer at three different diffusers and establish the feet per minute.

MAJOR BLOCK Air Conditioning **NAME** _____

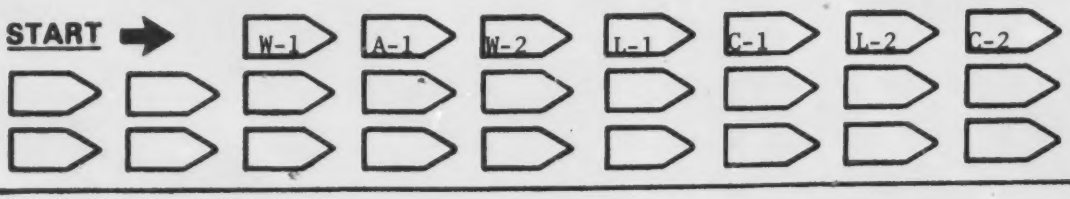
TASK Air Conditioning Fundamentals

UNIT Identifying Air Filtering Systems **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-05

OBJECTIVE(S)

Identify and install air filters



WRITTEN ASSIGNMENT(S)

W-1	Text Assignment AC-05a
W-2	Information Sheet AC-05a
W-3	
W-4	
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set AC-05a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet AC-05a
L-2	Job Sheet AC-05b
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

One important feature of year-round air conditioning is clean filtered air. Often the benefits which come from filtered air are taken for granted and no thought is given to the source of contamination.

If the technician were to study a recently occupied room, much air-borne contamination would be found. This contamination appears in the form of regular household dust, lint from clothing, tobacco smoke, street dirt from shoes, possibly some industrial waste and many others. It is the responsibility of the technician to determine not only sources of contamination but effective means of controlling it.

The principle method used to control household (as well as industrial) contamination is through a filtering system. For commercial applications the primary types of filters are roll, impingement and pleat, each having three basic categories -- minimum efficiency, interception, and high efficiency. Each of these types of filters has its best application based on efficiency versus the type of particles to be filtered out.

Job Sheet AC-05a

Using the previous information sheet, text assignments, and illustrations, remove and replace or service both a throw-away filter and a cleanable metal filter assigned by the instructor.

Using the previous information sheet, text assignments, and manufacturing manuals operate and troubleshoot an electronic air filtering system.

MAJOR BLOCK Air Conditioning **NAME** _____

TASK Window Air Conditioning

UNIT Installation of a Window Unit **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-06

OBJECTIVE(S)

Install a window air conditioning unit according to manufacturer's specifications.

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet AC-06a
W-2 Information Sheet AC-06b
W-3 Information Sheet AC-06c
W-4
W-5
W-6
W-7

AUDIOVISUAL(S)

A-1 AC-06a
A-2
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet AC-06a
L-2 Job Sheet AC-06a
L-3
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4
C-5
C-6
C-7
C-8
C-9

Installation of Window Units

It is very important for any piece of equipment to be installed correctly. A window air conditioner is no exception. Proper installation insures a quiet, trouble-free operation of a good air conditioner. Installation of the window unit requires the following list of tools:

1. Hacksaw
2. Screwdrivers (assorted)
3. Hacksaw
4. Nutdrivers
5. Hammer
6. Adj. wrench 6" and 8"
7. Handsaw
8. Screw assortment
9. Permagum
10. Drill
11. Knife
12. Sidecutters

Most new units will have detailed instructions for installation. However, there are situations where the manufacturer's directions are not available. The following slide set is for general applications and can be applied to most any installation job.

The instructor will assign a window air conditioner to inspect. Record the necessary information below and tag the following parts:

1. evaporator
2. condenser
3. fan
4. filter
5. chassis
6. compressor

Unit Serial Number _____

Comments:

Before installing the W/AC it is necessary to recognize the cabinet parts identified by the manufacturer. The window part names must also be memorized. These are shown in Figures A and B.

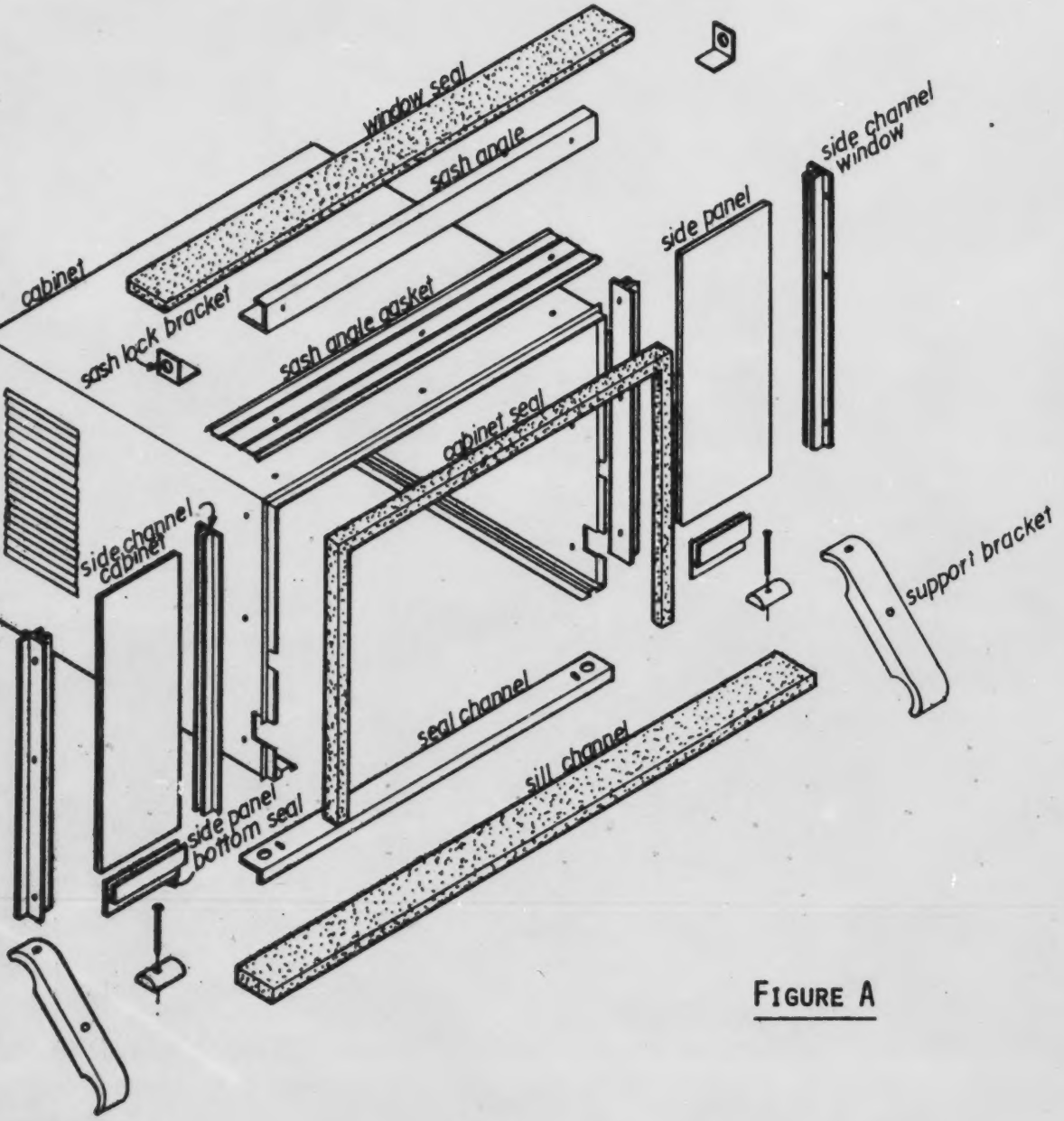


FIGURE A

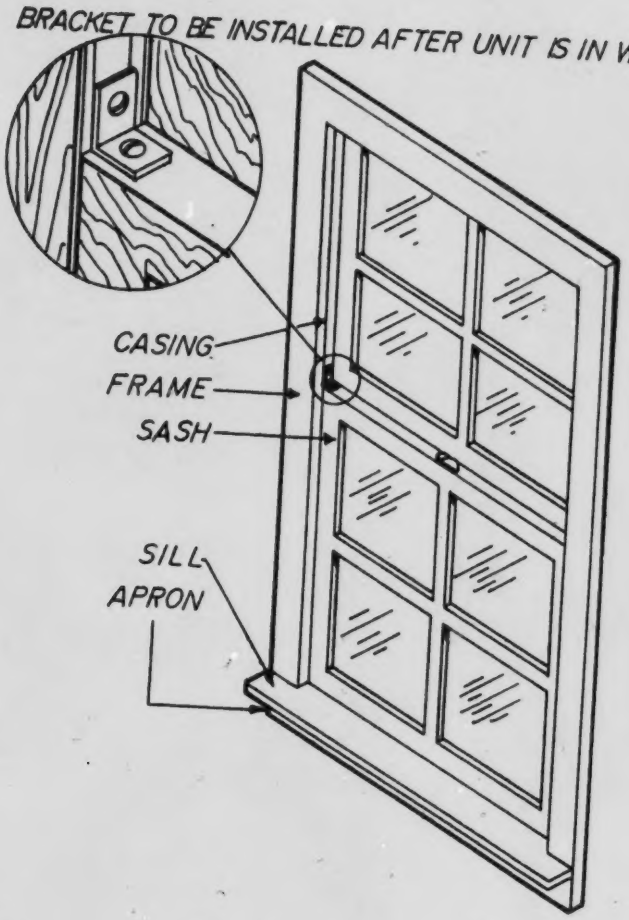

BRACKET TO BE INSTALLED AFTER UNIT IS IN WINDOW.
CASING
FRAME
SASH
SILL
APRON

FIGURE B

The instructor will assign a W/AC that contains the installation instructions. Read the instructions carefully and install the W/AC in a mock-up window.

Observe the following points:

1. Adequate wiring is available.
2. Unit must have a 1/8" to 3/8" drop from front to back. This insures condensate water will drain to outside.
3. Unit must be secure.
4. Window must be blocked from opening.
5. No air leaks around A/C.
6. Check for filter.
7. Make sure customer understands operation.

The following is a list of items that should be discussed with the customer before considering the job complete.

1. Tell the customer to wait 5 minutes before cutting W/AC back on after cutting it off as it will blow fuses or damage the unit.

2. The filters must be cleaned at least once a month. (Never run without filter).

3. Oil fan motor once a year.

4. Keep hedges and bushes clear of outside coil.

5. Explain reason for using time-delay fuse.

6. Advise customer to cover the outside section of the A/C during the winter.

MAJOR BLOCK Air Conditioning **NAME** _____

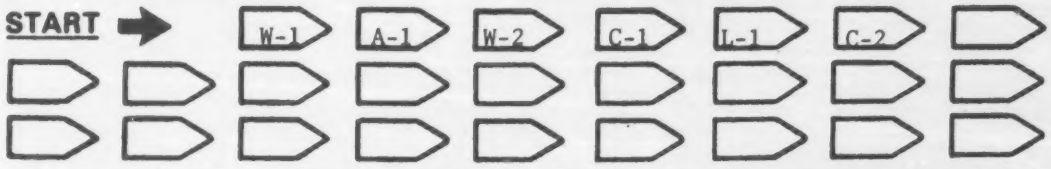
TASK Window Air Conditioners

UNIT Performing Pre-Season Start Up **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-07

OBJECTIVE(S)

Inspect and perform a pre-season start up for an air conditioning window unit.



WRITTEN ASSIGNMENT(S)

W-1 Information Sheet AC-07a
W-2 Assignment Sheet AC-07a
W-3 _____
W-4 _____
W-5 _____
W-6 _____
W-7 _____

AUDIOVISUAL(S)

A-1 Slide Set AC-07a
A-2 _____
A-3 _____
A-4 _____
A-5 _____
A-6 _____
A-7 _____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet AC-07a
L-2 _____
L-3 _____
L-4 _____
L-5 _____
L-6 _____
L-7 _____
L-8 _____
L-9 _____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 _____
C-4 _____
C-5 _____
C-6 _____
C-7 _____
C-8 _____
C-9 _____

What is pre-season start up?

Pre-season start up is preventive maintenance procedure. This preventive maintenance assures the customer of maximum cooling and maximum life of their window unit.

When should pre-season start up be performed?

Preventive maintenance should be performed in early spring or before the unit is used for the next cooling season.

Can customers perform pre-season start up?

Yes! To some degree they can. If the service technician informs the customer how to clean or change the filter, oil the fan motor, and wash out the coils with water hose, the customer can extend the life of the unit as well as get maximum cooling for each watt of electricity used.

Assignment Sheet AC-07a

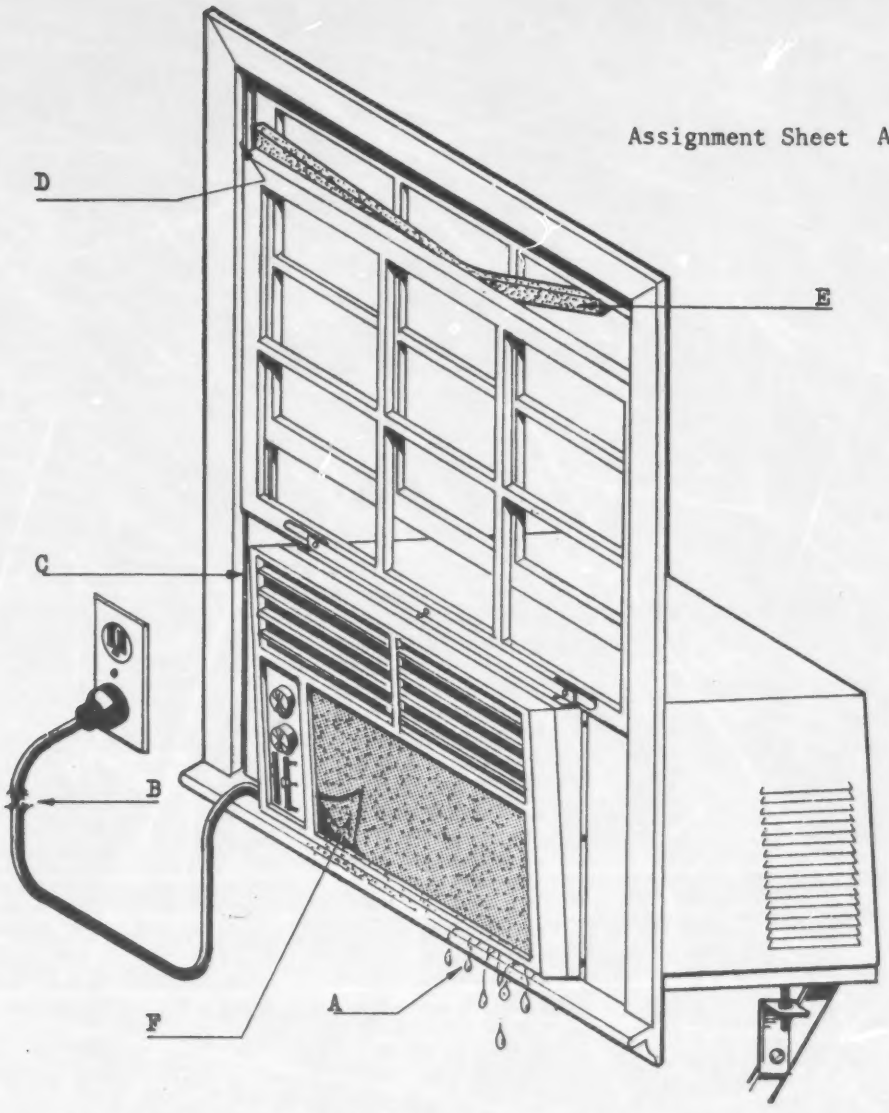


FIGURE A

After viewing AV-REF-28a list below what you think is wrong with the above air conditioner.

A -

B -

C -

D -

E -

F -

Using a mounted, serviceable window air conditioning unit and the following check list perform the pre-season service in the order prescribed.

PROCEDURE	CHECKED		WORK PERFORMED
	ok	needs repair	
1. Start up unit prior to inspection			
2. Visual Inspection			
a. rotten wood around window			
b. cracks in seals and windows			
c. water leaks			
d. dirty filter			
e. dirty coils			
f. tilt of unit			
g. condition of unit braces			
h. condition of receptacle and cord			
3. Perform Operations			
a. remove unit			
b. oil fan motor			
c. wrap fan motor with plastic			
d. clean coils			
e. straighten fins			
f. clean evaporator drains			
g. repair bracing			
h. tilt unit to outside (1/8 to 3/8 inch)			
i. repair window (rotten wood)			
j. repair or replace damaged and/or missing seals			
k. re-install unit			
l. clean filter			
m. repair cord			
n. repair receptacle			
o. start up and run			
p. check inlet and outlet temperatures			
q. repair water leaks			
r. clean area			
s. inform customer of maintenance procedures			

COMMENTS

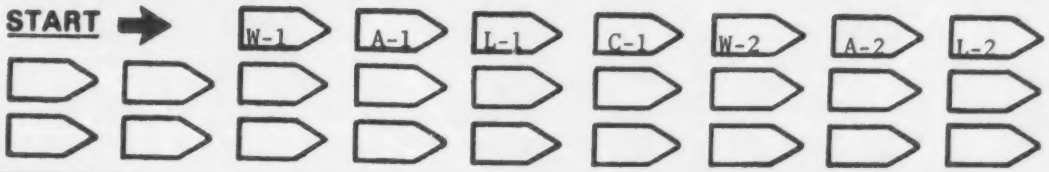
MAJOR BLOCK Air Conditioning **NAME** _____

TASK Window Air-Conditioners

UNIT Troubleshooting Burnout **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-08

OBJECTIVE(S) Troubleshoot a compressor burnout in a window air-conditioners



WRITTEN ASSIGNMENT(S)

W-1 Information Sheet AC-08a

W-2 Information Sheet AC-08b

W-3 _____

W-4 _____

W-5 _____

W-6 _____

W-7 _____

AUDIOVISUAL(S)

A-1 Slide/Script AC-08a

A-2 Slide/Script AC-08a

A-3 _____

A-4 _____

A-5 _____

A-6 _____

A-7 _____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet AC-08a

L-2 Job Sheet AC-08b

L-3 _____

L-4 _____

L-5 _____

L-6 _____

L-7 _____

L-8 _____

L-9 _____

CHECKPOINT(S)

C-1 Instructor Check

C-2 Instructor Check

C-3 _____

C-4 _____

C-5 _____

C-6 _____

C-7 _____

C-8 _____

C-9 _____

Replacement of a Burned Out Compressor

1. The instructor will assign a unit on which the compressor will be replaced.
2. Follow the procedures and replace the compressor in a window air-conditioner as if it were a severe burnout.
3. Bleed refrigerant by cutting a small cut with a hack saw on the compressor stub or on the strainer coming from condensor. (Be sure and put a rag around cut to catch the oil. The oil is potentially dangerous because of acid content. Do not allow it to touch the skin).
4. Remove wiring from the compressor during bleed off.
5. After making sure that the unit has been bled and the system has no pressure on it, unbraze the lines from the compressor. (Be sure not to stand over or directly in front of the line to be removed. (Oil may squirt out which is burning. Also deadly phosgene gas may engulf you.)
6. Remove mounting bolts, brackets, etc.
7. Mash lines on old compressor and seal.
8. Lift out compressor. (Be careful not to spill oil or touch the oil if the compressor is not sealed.)
9. Set new compressor in place. (Do not hook up lines.)
10. Remove drier or filter and capillary tubes by cutting from line with tubing cutter or hack saw.
11. Flush R-12 through the evaporator and condensor. This procedure needs to be done in a well ventilated area and with the instructors help.
12. Install new capillary tube(s). Use capillary sizing chart to determine proper size. (Depending on the severity of the burnout, capillary tubes may or may not need to be removed).

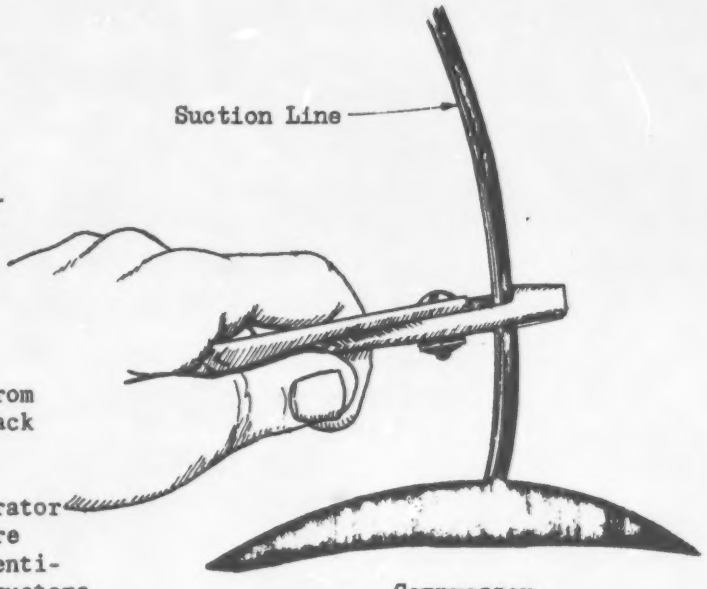


FIGURE A

13. Install new filter or oversized filter dryer in the liquid line.
14. Re-install all lines.
15. Leak check the lines.
16. Evacuate the system.
17. Install all wiring.
18. Charge the system.
19. Check for proper operation.

Compressor Burnout

A compressor burnout exists when a compressor fails to operate electrically due to open windings, grounded windings, open internal overload, shorted windings or any combination of these problems.

There are many reasons for compressor burnout, but some of the more common are:

1. Lightning which causes a very high voltage surge, and literally melts the windings and insulation.
2. Problems due to faulty electrical components that control the compressor may exist (capacitor, overload, relay, oversized fuses).
3. Low voltage due to improper installation (wiring too small), or bad contact in switch receptacle.
4. Insufficient cooling to compressor windings due to low charge and high head pressure.
5. Faulty compressor windings or bad bearings in motor.

The instructor will provide three compressors, the student will determine a faulty compressor from a good one. If additional information is needed, review Slide Set REF-29a.

Tools Needed:

1. VOM
2. Compressor test cord
3. Amprobe
4. File
5. Screw driver

Equipment Needed (three compressors):

1. One will be grounded.
2. One will have open windings.
3. One will be operational.

Procedures:

1. Check all three compressors for grounded windings with VOM Meter. Set meter on RX100 and ground one lead to the dome, be sure to scratch a bare place, touch each terminal with the other lead. Any reading suggests a bad compressor.
2. Check the compressor for open windings. Set meter on RX1. Check and record continuity on all three terminals.
3. Determine the start, common, and run terminals of the compressor that checked good with VOM and start the compressor.
4. Record your findings on the following page.

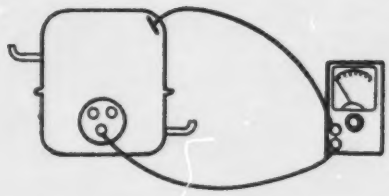
Please give the following information on your work.

1. Was the compressor grounded to the dome?

   Compressor #1 _____

   Compressor #2 _____

   Compressor #3 _____

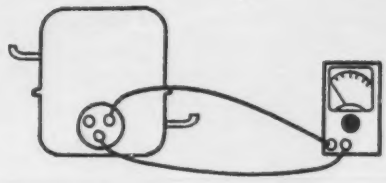


2. Did the compressor have a open winding?

   Compressor #1 _____

   Compressor #2 _____

   Compressor #3 _____

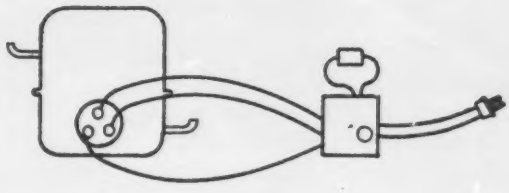


3. Would the compressor start?

   Compressor #1 _____

   Compressor #2 _____

   Compressor #3 _____



Please circle:

Compressor #1	Compressor #2	Compressor #3
Good	Good	Good
Bad	Bad	Bad

When compressor burnout occurs, the system becomes contaminated with carbon and sludge. Also, in the presence of heat and moisture hydrochloric acid will form. Oil in this conditon is termed "acidic". If the system is not thoroughly flushed out, this acid will cause the insulation on the windings of a new compressor to rapidly deteriorate and short circuit the unit.

Do not touch the oil from a burned out unit, as it will cause severe acid burns. Do not allow the oil to run on the floor. Trap the oil in a suitable container. Burned out compressors will have a very unpleasant odor. If there is no odor present and the oil is clean, chances are the compressor did not burn out.

Burned out compressors are not repaired in the field. The compressor is replaced with a new or rebuilt unit. The following audio-visual will detail the replacement job.

MAJOR BLOCK Air Conditioning **NAME** _____

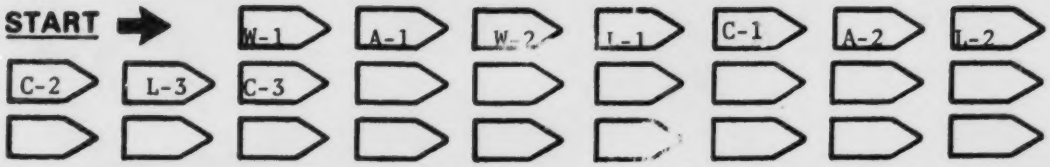
TASK Window Air Conditioners

UNIT Evacuating and Charging **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-09

OBJECTIVE(S)

Evacuate and charge window air conditioners.



WRITTEN ASSIGNMENT(S)

W-1 Information Sheet AC-09a
W-2 Text Assignment AC-09a
W-3 _____
W-4 _____
W-5 _____
W-6 _____
W-7 _____

AUDIOVISUAL(S)

A-1 Slide/Script AC-09a
A-2 Slide/Script AC-09b
A-3 _____
A-4 _____
A-5 _____
A-6 _____
A-7 _____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet AC-09a
L-2 Job Sheet AC-09b
L-3 Job Sheet AC-09c
L-4 _____
L-5 _____
L-6 _____
L-7 _____
L-8 _____
L-9 _____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 _____
C-5 _____
C-6 _____
C-7 _____
C-8 _____
C-9 _____

A window unit system must be evacuated anytime a repair to the refrigeration cycle is performed or refrigerant is replaced.

Window units do not normally work at low enough temperatures to freeze moisture in the unit and restrict refrigerant flow. Occasionally, however, this condition will exist. Moisture is a continuous problem in the refrigeration industry, because it contaminates the oil and causes corrosion. Acids are formed which will deteriorate metals and compressor windings. To remove these dangers, be sure that equipment and components are kept clean and always evacuate the system when repair work is performed on the refrigeration cycle.

The triple evacuation method is the fastest and easiest way to evacuate the system. For window air-conditioners it is the most practical.

The following slides will demonstrate this method.

Evacuating a Window Air-Conditioner

1. The instructor will assign a window unit for this activity.
2. Install process valve on suction and discharge lines.
3. Install service manifold.
4. Evacuate system using triple evacuation method.
5. Put a holding charge on unit. (This means put enough refrigerant in the system to bring the system's internal pressure up to 0 (zero) pounds per square inch guage.)

*Do not charge the system at this point.

Charge a unit using the temperature, pressure, and touch method.

1. Gain access to the unit.
2. Make any repairs needed and leak check the refrigeration lines.
3. Evacuate the system.
4. Pressurize up to 70 to 80 pounds per square inch guage of proper refrigerant.
5. Start up air-conditioner.
6. Let refrigerant in through low side in gas state. (Tank may need to be put in warm water.) Never heat tank with a torch.
7. Look at where the cap tube enters the evaporator. Frost should be visible at first.
8. Keep adding refrigerant to low side in gas state. When frost disappears from evaporator on the entire coil, the unit is almost fully charged.
9. The suction pressure should climb slowly and continuously while the unit is charging. (If the system stays in a vacuum, it is likely that a restriction exist.)
10. When all the frost has disappeared from the evaporator, feel the suction line. It should be fairly cool to the touch. The suction line surface should have moisture all the way to the compressor.
11. Check your temperature drop across the coil. If the temperature drop is from 15 to 20 degrees Fahrenheit drop, the unit is probably fully charged. Remember, the most possible temperature drop is desirable.
12. Close and seal the unit.

NOTE: When charging a window air-conditioner or any refrigeration system, don't get in a hurry. Take your time and use your senses of touch and sight to guide you.

Charge a unit with the Dial-a-charge method. Use the following procedures to guide this activity:

1. Determine the window air-conditioner charge to the ounce.
2. Put approximately 8 ounces more refrigerant in Dial-a-charge than needed.
3. Let Dial-a-charge pressure equalize while evacuating unit.
4. Charge window air-conditioner with holding pressure from Dial-a-charge.
5. Start the window air-conditioner.
6. Charge the unit with gas vapor from Dial-a-charge.
7. Put the exact charge in the unit.
8. Check temperature drop.
9. Close and seal the unit.

NOTE: If a suction line filter or extra tubing has been added, an exact charge cannot be determined. In this case you would have to use temperature, pressure, touch method.

MAJOR BLOCK Air Conditioning **NAME** _____

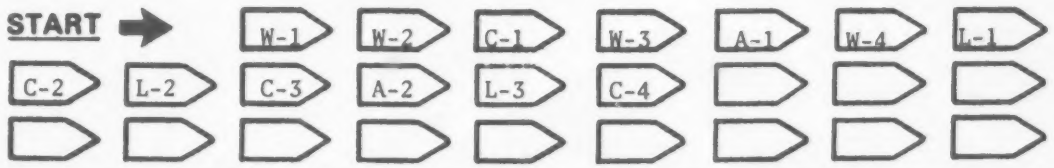
TASK Window Air Conditioner

UNIT Troubleshoot Fan and Fan Motors **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-10

OBJECTIVE(S)

Troubleshoot and replace the fan and fan motor on a window air-contioning unit.



WRITTEN ASSIGNMENT(S)

W-1	Information Sheet AC-10a
W-2	Assignment Sheet AC-10a
W-3	Information Sheet AC-10b
W-4	Text Assignment AC-10a
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set AC-10a
A-2	Slide Set AC-10b
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet AC-10a
L-2	Job Sheet AC-10b
L-3	Job Sheet AC-10c
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	Instructor Check
C-5	
C-6	
C-7	
C-8	
C-9	

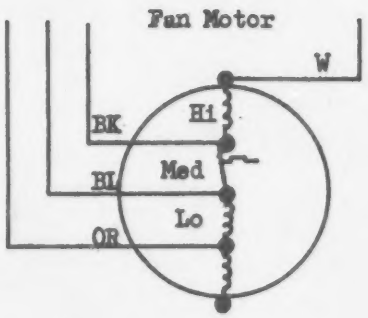
Window air conditioner manufacturers use two types of fan motors in their air conditioning. The shaded pole motor is used because of its simple design and low starting-torque. The permanent split capacitor motor is used because of its relative low cost compared to other motors and its moderate starting-torque.

Manufacturers usually prefer the permanent split capacitor motor because it has slightly more starting power than the shaded pole motor. For this reason more fan speeds are possible. The easiest way to recognize the permanent split-capacitor motor is by checking for a run capacitor. This can usually be identified by reading the schematic of the motor to identify the run capacitor.

Although not preferred as often by manufacturers of window air conditioners, the shaded-pole motor is used extensively where only low starting power is needed. Its simple design permits air-conditioner service technicians to easily diagnose and service problems.

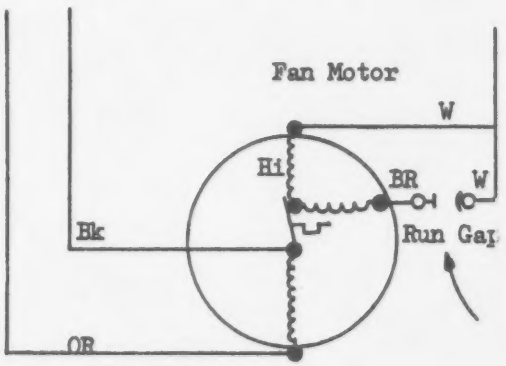
Shaded-pole Motor Schematic

A-1



PSC Motor Schematic

A-2



Fan motors usually go bad because of mechanical or electrical failure. Usually mechanical failure is due to bad bearings, a warped shaft, warped end bells, or some other problem not relating to electricity. Electrical failure usually results from open, grounded, or shorted windings.

Many of the problems which occur with an electric motor may be easily identified. Some of the symptoms which might suggest that a motor is defective are:

(a) motor will not start

(b) motor starts but very slow to come up to speed

(c) bad bearings - shaft can be moved in an upward or downwards direction; shaft wobbles

(d) there is arcing in the motor

(e) excessive humming noise

(f) smoke from motor

(g) excessive blown fuses or circuit breaker trips

1. The instructor will assign three window units or three fan motors for this activity. Determine whether each motor is a shaded pole or a permanent split capacitor (PSC).

2. Complete the following information for each motor.

	Serial Number	Size/HP	Shaded Pole/PSC
Motor #1	_____	_____	_____
Motor #2	_____	_____	_____
Motor #3	_____	_____	_____

The following information will be helpful in diagnosing fan motor troubles.

1. Look on the motor or on the unit for an electrical wiring diagram.

2. Determine what wires go to each component and identify them by color or number.

3. Carefully zero the ohmmeter on the R x 1 position.

4. When you test a motor winding, you should consider the following:

   (a) If the ohmmeter goes all the way to zero side of the scale, you probably have a direct short.

   (b) If the ohmmeter stays on infinity, you have an open winding.

   (c) All windings should have a resistance reading, and different speeds will read different resistances.

The instructor will assign a window unit on which motor windings can be checked by the "Direct Test" method.

1. Always check voltage before performing the direct test on the fan motor.

2. Check fan capacitor if applicable. (Only if motor is capacitor start).

3. Disconnect power from unit.

4. Disconnect the fan motor leads (refer to wiring schematic) (Make direct test with fan motor in place and fan blades in the proper position).

5. Place the time-delay fuse into direct test socket (15 amp).

6. Connect leads to the fan motor.

   (a) Connect run lead to main winding lead of the fan motor. (Main winding lead is usually white).

   (b) Connect common lead to high speed lead of the fan motor. (High speed lead is usually black).

   (c) Connect start lead to start winding lead on capacitor start fan motors. (Start winding lead is usually brown).

   (d) Connect ground lead to bare metal component on unit. (If no ground lead is provided add one between wall receptacle "ground" and bare metal component on unit).

   (e) With direct test switched "off," plus power supply leads into the voltage outlet.

   (f) Turn the switch "ON."

   (g) Refer to Information Sheet REF-31b to identify symptoms.

      A. Unit serial number _____

      B. Diagnosis _____

      C. Repair needed _____

The instructor will assign a window unit on which the fan and the fan motor can be removed. Use the following procedures:

1. Remove the top cover and as many covers as possible to make the motor accessible.

2. Unplug the electrical wires. Notice their numbering system, and how they are connected.

3. If the wires are not numbered, identify them in some way (such as masking tape with numbers hand lettered---remember to remove masking tape when the job is completed).

4. The motor is probably held in position with bolts or clamps. These must be removed.

5. The fan blades may have to be removed to get the motor out.

6. Determine how to remove the fan. Look for set screws or some other type of holding mechanism.

7. Remove the fan motor.

8. Replace the fan motor and reconnect all wiring.

9. Check the motor for proper operation.

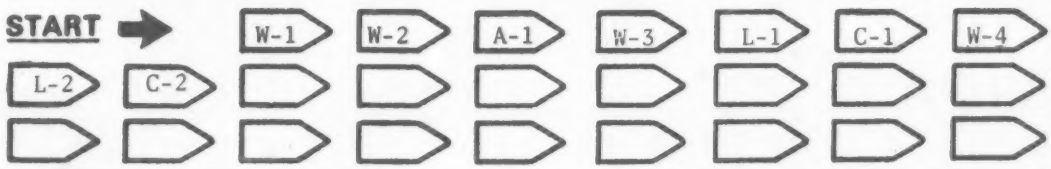
MAJOR BLOCK Air Conditioning **NAME** _____

TASK Window Air Conditioning
Troubleshooting Window Air

UNIT Conditioning (Refrigeration Cycle) **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-11

OBJECTIVE(S) Troubleshoot the refrigeration cycle of a window air conditioner



WRITTEN ASSIGNMENT(S)

W-1	Information Sheet AC-11a
W-2	Text Assignment AC-11a
W-3	Text Assignment AC-11b
W-4	Information Sheet AC-11b
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set AC-11a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet AC-11a
L-2	Job Sheet AC-11b
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

Troubleshooting a Window Air Conditioner Mechanical Refrigeration Cycle

1. What is troubleshooting a window air conditioning refrigeration cycle? Put simply, it is finding what is wrong with the mechanical cooling portion of a window air conditioner and then replacing it.

2. Is it difficult to learn how to troubleshoot the refrigeration cycle? No, if the student has successfully completed and understood the previous units, it is simply checking for what should be happening but isn't.

3. Can I learn how to troubleshoot a window air conditioner? Probably yes, it is really quite simple. The student must study and learn what the window air conditioner should be doing and then take complaints of what it isn't doing and check to see why.

4. What is the most common problem with the refrigeration cycle? Probably, the biggest problem is dirt. If either the evaporator or condenser is dirty and stopped up the unit will not operate properly.

5. How do I troubleshoot a unit? Use good judgement and think things out before tearing something apart. Troubleshooting is learned through experience and this unit is designed to give some basic experience in that regard.

1. The instructor will assign an air conditioner that is working properly.
2. Remove cabinet exposing discharge and suction lines.
3. Plug the unit into proper voltage source and check for proper operation.
4. Record findings where indicated.
5. Replace all equipment and tools.

***REMEMBER TO WATCH WHERE YOU PUT YOUR HANDS!!!

Please circle findings.

1.	Suction line temperature	Cool	Warm	Hot
2.	Discharge line temperature	Cool	Warm	Hot
3.	Condenser discharge air temperature	Cool	Warm	Hot
4.	Evaporator discharge air temperature	Cool	Warm	Hot
5.	Liquid line temperature	Cool	Warm	Hot

Record findings.

6. Evaporator air drop _____ ^{o}F
7. Discharge Pressure _____ PSIG
8. Suction Pressure _____ PSIG
9. Does this unit seem to be cooling? _____
10. Does unit seem to be cooling efficiently? _____
11. Do the coils seem to be dirty? _____
12. In your opinion, is this unit working properly? _____

REFRIGERATION CYCLE COMPLAINTS

Complaint	Possible Causes	Tests-Repairs
1. Compressor runs constantly- will not cycle off	(a) Restriction in line	(a) Check for iced area along capillary or liquid line. Make certain frost is not caused by dirty or blocked evaporator. Test for high current. (Replace cap tube if it is restricted).
	(b) Leak in system.	(b) Check evaporator coil after 10-15 minutes of operation. If not cooling, check for leaks and repair.
	(c) Restricted air flow.	(c) Check each coil for dirt accumulation. Clean if needed.
2. Not enough cooling.	(a) Excessive heat load.	(a) Heat is building up faster than window air conditioner can absorb. Check cooling performance for need of larger unit.
	(b) Not enough ventilation for condenser.	(b) Change location of window air conditioner.

(c) Evaporator/Condenser fans dirty or plugged blocking air flow.	(c) Clean fins (brush, vacuum, clean, etc.)
(d) Partial or complete restriction in tubing.	(d) Check for frosted capillary or liquid line. (Make sure coil is not restricted by dirt which would cause frosted evaporator). Check for high running current. If restricted replace.
(e) Bad valves in compressor.	(e) Replace compressor if suction and discharge pressure are very close together. (A compressor that will not pump may have a cool discharge line).

1. Determine (from information given in previous units) whether to enter the refrigeration system.

2. Decide what type of service valves to use. (Remember that it is best to have access to both the high and low sides).

3. Install access valves (according to previous units and manufacturer's recommendations).

4. Write down the gauge pressures before starting the air conditioner. Record both the high side and low side pressure, the drop across the evaporator, and ambient air temperature. Ambient air temperature is the surrounding outside temperature of the condenser.

5. Remember to look over and touch components, checking for anything out of the ordinary.

6. Cut machine off and try and determine what the problem is.

7. Repair the problem.

8. Seal the unit (using previous units as a guide). (Remember to always evacuate a unit after working on refrigeration cycle).

1. The instructor will assign a window air conditioner to work on. There is a problem with the refrigeration cycle. Gain access to the system, record needed data below, and check with troubleshooter's chart to determine possible cause.
2. Describe problem to instructor.
3. Repair problem.

Check	Record	Procedure
1. Evaporator Temp. Drop.	_____ ^{o}F	Use thermometer
2. Suction line	Frost, CVO (sweating), warm pressure	Touch with fingers
3. Discharge line	warm-hot pressure	Touch lightly
4. Condenser	dirty - clean warm - hot - both	eyesight
5. Evaporator	dirty - clean wet - dry frost - no frost	eyesight
6. Metering device (cap tube)	dry - wet kinks - no kinks warm - cold	eyesight eyesight - touch touch
7. Strainer or dryer (just before cap tube)	dry - wet cold - warm - hot	eyesight touch
8. Compressor	cold - warm - hot noisy - quiet amperage	touch eyesight amprobe (ammeter)
9. Condensate	none - little - lot	eyesight
10. Filter	clean - dirty - none	eyesight

MAJOR BLOCK Air Conditioning **NAME** _____

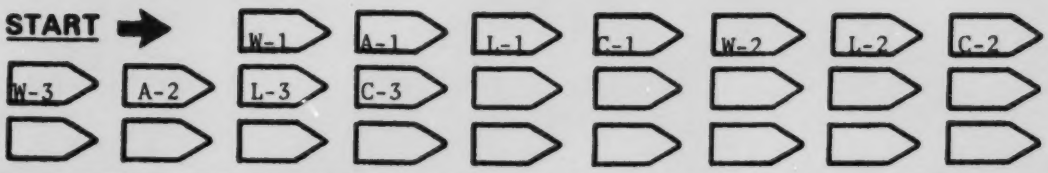
TASK Window Air Conditioning

UNIT Troubleshooting a Window Air Conditioner Electrical System **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-12

OBJECTIVE(S)

Locate electrical problems in a window air conditioner.



WRITTEN ASSIGNMENT(S)

W-1 Information Sheet AC-12a
W-2 Text Assignment AC-12a
W-3 Information Sheet AC-12b
W-4 _____
W-5 _____
W-6 _____
W-7 _____

AUDIOVISUAL(S)

A-1 Slide Set AC-12a
A-2 Slide Set AC-12b
A-3 _____
A-4 _____
A-5 _____
A-6 _____
A-7 _____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet AC-12a
L-2 Job Sheet AC-12b
L-3 Job Sheet AC-12c
L-4 _____
L-5 _____
L-6 _____
L-7 _____
L-8 _____
L-9 _____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 _____
C-5 _____
C-6 _____
C-7 _____
C-8 _____
C-9 _____

Approximately 90% of all problems with window air conditioners are electrical. In troubleshooting the window unit there are three areas of learning that must be mastered. They are:

1. Identifying all the part names and functions.
2. Reading wiring diagrams.
3. Checking each component with a meter.

There are only two running parts that use electricity. They are the fan motor and compressor motor. The remainder of the electrical system either controls or protects thest two components. Using knowledge gained from previous units the electrical system can be easily checked.

Reading Wiring Diagrams

1. The instructor will assign a W/AC with a wiring diagram attached.
2. Find the voltage supply lines going to the fan motor and compressor and record color code.
3. Determine which is common, run, and start on the compressor and label.
4. Determine whether the fan motor is shaded pole or a permanent split capacitor type and record below.
5. Determine how many speeds the fan has and what color wire controls that that speed and record below.
6. Find thermostat and overload, and label.
7. Find capacitor and start winding, and label.

Unit Serial Number _____

Supply Voltage Color Codes _____

Fan Motor Type _____

Fan Motor Speeds and Color Codes _____

_____

_____

1. The instructor will assign a window air conditioner to identify components. Record the unit serial number below.

2. Locate and tag the following components:

   a. compressor
   b. fan motor
   c. capacitor
      (1) single type
      (2) dual type
   d. main switch
   e. thermostat
   f. overload

Unit Serial Number_____

The following is a "troubleshooting chart" to be used in diagnosing problems that occur in the window air conditioner. As can be seen on the chart, several different defects can cause similar problems. It is the technician's responsibility to identify the correct problem as quickly as possible. You may want to use this chart with the next Job Sheet REF-32c.

WINDOW AIR CONDITIONER - TROUBLESHOOTING CHART

Problem	Possible Cause	Repair or Service Needed
Unit inoperative	a. No power	a. Check for good plug contact, fuses of correct size, and time-delay type.
	b. Low voltage	b. Raise voltage if more than 10% below nameplate rating. Improve wiring and/or use transformer.
	c. Incorrect wiring or defective	c. Check correctness of wiring and connections. Check operation of switches, all thermostats, relays, overload, compressor, fan motor, capacitors, transformers, etc.
Fan runs but compressor does not	a. Incorrect power supply	a. Check for proper voltage.
	b. Defective component or incorrect wiring	b. Check correctness of wiring and connections. Check operation of switches, all thermostats, relays, overload open or shorted starting capacitor, shorted run capacitor.
Compressor runs but fan does not	a. Blower wheel or fan blade binding	a. Check for proper clearances.
	b. Defective component or incorrect wiring	b. Check correctness of wiring and connections. Check operation of all switches, thermostats, de-icer controls, shorted capacitor, defective reactor or fan motor.
	c. Defective reactor or incorrect wiring.	c. Check reactor and wiring

Problem	Possible Cause	Repair or Service Needed
Compressor runs but fan does not (cont'd)	d. Defective controlling relay (remote control models).	d. Check relay and wiring.
No cooling but compressor and fan are operating	a. Air flow restriction	a. Dirty filter. Air passages obstructed.
	b. Compressor not pumping	b. Check for low wattage, restriction, loss of refrigerant, low capacity compressor.
Insufficient cooling - compressor and fan operating	a. Improper air flow	a. Dirty filter. Air passages restricted or obstructed. Exhaust door open. Dirty condenser, evaporator or fans.
	b. Compressor not pumping at full capacity.	b. Check for low wattage, low voltage, low capacity compressor, restriction, loss of refrigerant.
	c. Operating 60 cycle unit on 50 cycle current	c. Advise customer unit is operating normally under these conditions if unit is delivering only 5/6 of 60 cycle operating output.
	d. Low voltage	d. Check power supply.
	e. Improper seals	e. Insulating seals out of place or missing on unit. Doors or windows open.
	f. Improper use	f. Excessive load. Advise customer if load is excessive or installation is incorrect or inadequate. Instruct on proper operation of thermostat and other controls.
	g. Fan motor too slow	g. Check for wrong motor, wrong blower wheel or fan blade. Low voltage - adjust top on reactor (if present). Check for binding of fan blade, blower wheel or motor shaft. Lubricate fan motor.
Compressor stops and starts - too short running time	a. Attempting to start unit too soon after shut off	a. Instruct customer of need for 2-minute wait for pressure equalization
	b. Incorrect voltage	b. Check for proper voltage.

Problem	Possible Cause	Repair or Service Needed
Compressor starts and stops - too short running time (cont'd)	c. Thermostat set too warm	c. Instruct customer.
	d. Defective thermostat	d. Check temperature thermostat and de-icer thermostat.
	e. Defective compressor, compressor controlling components, incorrect wiring	e. Check compressor windings, all wiring, overload, relay, starting and/or running capacitor for shorts.
	f. Fan motor too slow	f. Check for wrong motor, wrong blower wheel or fan blade. Low voltage - adjust top on reactor (if present). Check for binding of fan blade, blower wheel or motor shaft. Lubricate fan motor.
House circuit fuses blowing	a. Improper fuses	a. Check for correct size and of time-delay type.
	b. Trying to start unit too soon after shut off.	b. Instruct customer of need for 2-minute wait for pressure equalization
	c. Improper voltage or incorrect wiring.	c. Check power supply, connections, all wiring. Improve wiring and/or use tranformer.
	d. Defective component or incorrect wiring.	d. Check correctness of wiring and connections. Check operation of switches, all thermostats, relays, overload, compressor, fan motor, capacitor, transformer, etc.
Noisy operation	a. Loose parts	a. Check shipping clamps, washers, tubing contact or vibration, loose screws, etc.
	b. Mounting area not firm.	b. Add support kit or improve construction.
	c. Compressor (could be overloaded due to high ambient or air flow restrictions)	c. Loose internally, no oil. Improper voltage.

Problem	Possible Cause	Repair or Service Needed
Noisy operation (cont'd)	d. Fan motor	d. Blower wheel or blade loose or hitting. Bad bearing.
	e. Defective or wrong capacitor	e. Check for secure mounting, correct part, correct wiring.
	f. Defective relay	f. Check for secure mounting, correct part, correct wiring, correct mounting position.
Evaporator frosts up	a. Low outside air temperature (below 70°).	a. Instruct customer that operation in these ambients is not considered normal requirement of unit.
	b. Thermostat defective or set too cold.	b. Check thermostat and/or instruct customer.
	c. Improper air flow.	c. Dirty filter. Air passages restricted or obstructed. Exhaust door open. Dirty evaporator coil. Dirty blower wheel. Loose blower wheel on shaft
	d. Fan motor too slow.	d. Using low fan speed; instruct customer. Improper reactor top. Low voltage; adjust reactor. Wrong motor or blower wheel. Check for binding of fan blade, blower wheel or motor shaft.
	e. Defective unit	e. Check for restriction or loss of refrigerant.
Moisture dripping into room	a. Extreme humidity	a. Advise customer of possible sweating formations under abnormal conditions. Check and improve all possible seals, minimize door opening.
	b. Inadequate seal	b. Check and improve all sealed areas.
	c. Improper leveling	c. Check for proper side-to-side level of cabinet and unit. Check for ¼" (or ½ to 1 full bubble on level) slope of cabinet toward outside.
	d. Moisture drain holes plugged	d. Check and clean. Advise customer of proper maintenance.

1. The instructor will assign a window air conditioner with an electrical problem. Record the Unit Serial Number below.

2. Using the VOM, tools and previous troubleshooting chart locate the problem.

3. Write down the problem in the space provided.

4. Write down what you think is required to put the unit back in operation.

W/AC Serial Number _____

Problems Found _____

_____

_____

_____

_____

_____

Work Required to Restore Unit to Operation _____

_____

_____

_____

_____

_____

MAJOR BLOCK Air Conditioning **NAME** _____

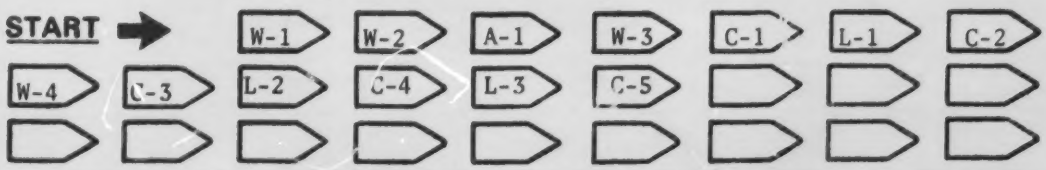
TASK System and Installation

UNIT Installing Condensate Drain **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-13

OBJECTIVE(S)

Identify and install condensate drain.



WRITTEN ASSIGNMENT(S)

W-1	Information Sheet AC-13a
W-2	Text Assignment AC-13a
W-	Assignment Sheet AC-13a
W-4	Assignment Sheet AC-13b
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set AC-13a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet AC-13a
L-2	Job Sheet AC-13b
L-3	Job Sheet AC-13c
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	Instructor Check
C-5	Instructor Check
C-6	
C-7	
C-8	
C-9	

The purpose of the condensation drain line (Figure A) is to dispose of the water accumulated on the evaporator coils. The amount of water that is accumulated will vary with the percentage of humidity in the air being conditioned. Keeping this variable in mind, the line should always be sized for the maximum amount of water, and at no time should the line be smaller than the drain line fittings on the coil.

All condensate drains must have a trap. Without a trap, the fan will pull unconditioned air and drain water up the drain. The trap must be so designed to overcome this pressure developed by the fan. If not, when the fan is cut off, the water falls in suspension inside the cabinet of the unit and runs out into or onto an undesirable location.

Most drains depends on gravity flow. They should be run as straight as possible and allowed maximum pitch or slope for proper drainage. One inch slope each ten feet of drain pipe is sufficient.

Sometimes there is no way to install the drain line with a gravity flow. When this happens, the installer must use a lift pump to remove the water up to a level where gravity can take over (Figure B).

A cut off switch may be installed in the drain pan to stop the air conditioning unit if the pan becomes overfilled with condensation due to a drain malfunction.

Plastic or pipe tubing is probably the most common material used for condensate drain line construction. It will not rust, has a smooth inside surface and is easy to work with. The bonding agent that is used to glue the plastic pipe together is a chemical that melts the plastic fitting resulting in a leak proof, tight fit. Make sure the fittings are in the correct position before pushing them together after the glue has been applied. The bond will occur very fast, and when it does there is no changing position.

Remember, if a person fails to install a drain properly, he or his company is liable for any damage caused by faulty workmanship.

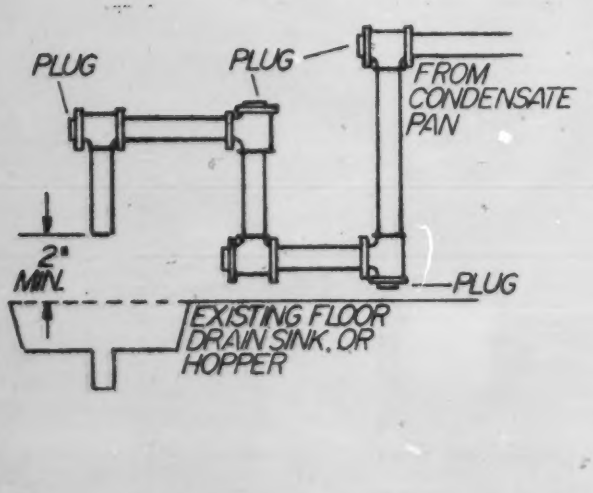


FIGURE A

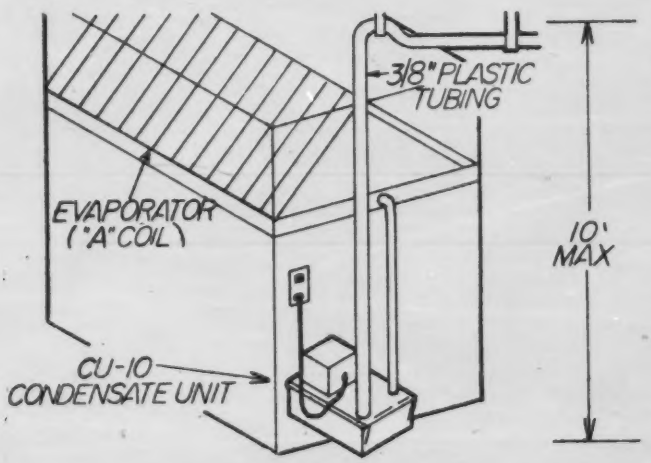


FIGURE B

Use the fittings, and piping in Figure C to design a proper drain for Figure D. Draw the necessary fitting and pipe into their appropriate position in Figure D and label the type and size. Make sure you specify the minimum slope of the piping and depth of the trap(s). Be sure to install clean out plugs.

FITTINGS FOR ABS PIPE

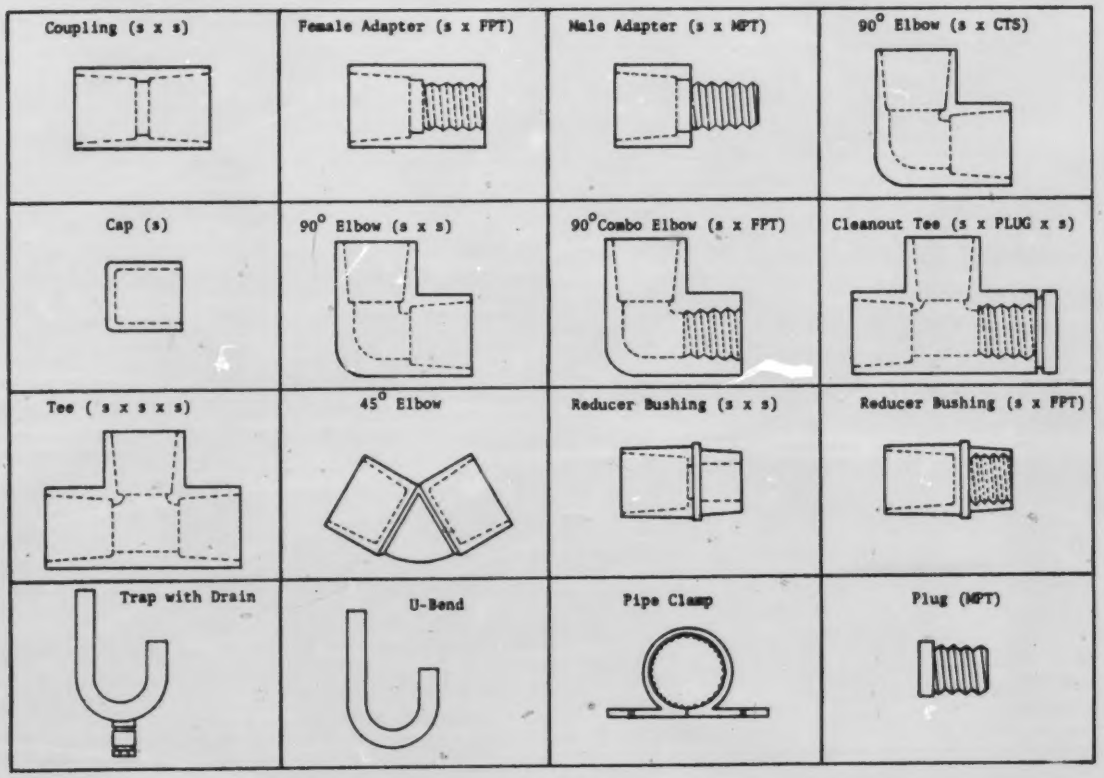

Coupling (s x s)
Female Adapter (s x FPT)
Male Adapter (s x MPT)
90° Elbow (s x CTS)
Cap (s)
90° Elbow (s x s)
90° Combo Elbow (s x FPT)
Cleanout Tee (s x PLUG x s)
Tee (s x s x s)
45° Elbow
Reducer Bushing (s x s)
Reducer Bushing (s x FPT)
Trap with Drain
U-Bend
Pipe Clamp
Plug (MPT)

FIGURE C

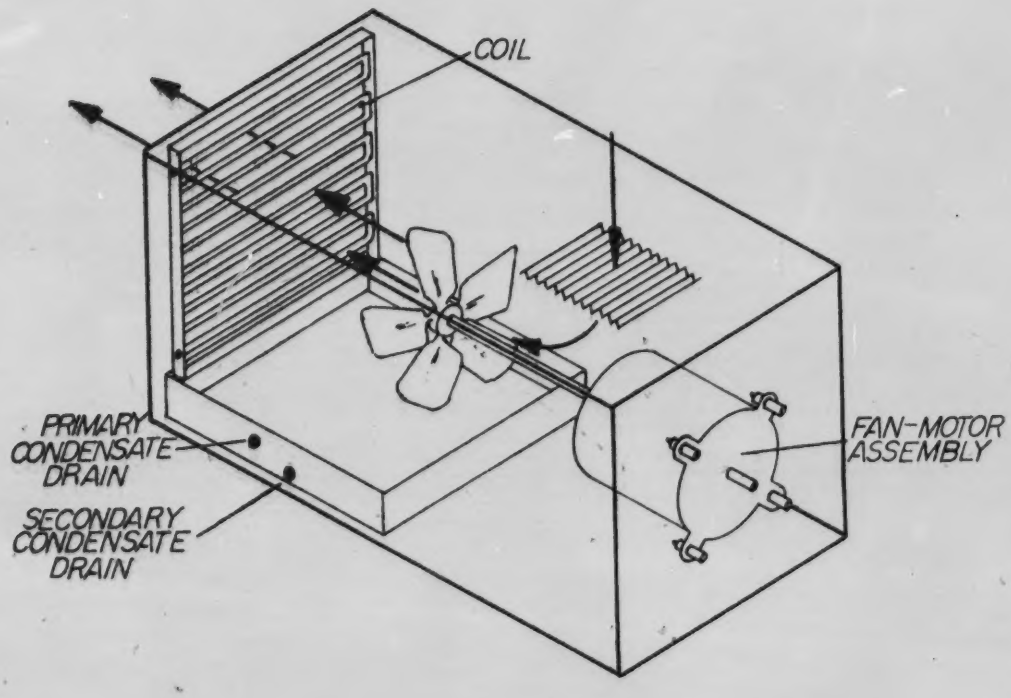

COIL
PRIMARY CONDENSATE DRAIN
SECONDARY CONDENSATE DRAIN
FAN-MOTOR ASSEMBLY

FIGURE D

PROCEDURES:

1. List the materials needed to complete a drain assigned to you by the instructor.

2. Secure materials needed to pipe the drain line.

3. Select a coil on an air conditioning system and run a gravity drain. DO NOT glue these fittings at this time.

4. Press all fittings together before gluing.

5. Disassemble and glue according to the following steps. (Gluing of piping should be done only at the direction of the instructor).

Gluing Instructions

A. Apply cement to pipe end to about the depth of fitting socket.
B. Insert pipe in fitting and twist ¼ turn to insure complete coverage.
C. Wipe off excess bead of cement with cloth.
D. Support pipe every 3' to 4' with plastic pipe clamps. Clamps should be loose enough to permit movement from expansion and contraction.
E. Use Pipe Thread Compound to seal threaded connections. Threaded connections should be hand tight plus one full turn with a wrench. **DO NOT USE CEMENT ON THREADED CONNECTIONS.**

The following illustration is a heating/air conditioning unit of the upflow design. Draw a proper drain taking into account that this tubing must not rest on or near the hot draft diverter and must pass by the edge of the filter rack. Specify what parts of the drain must be metal and what should be plastic. Use plastic part numbers from Assignment Sheet AC-13a.

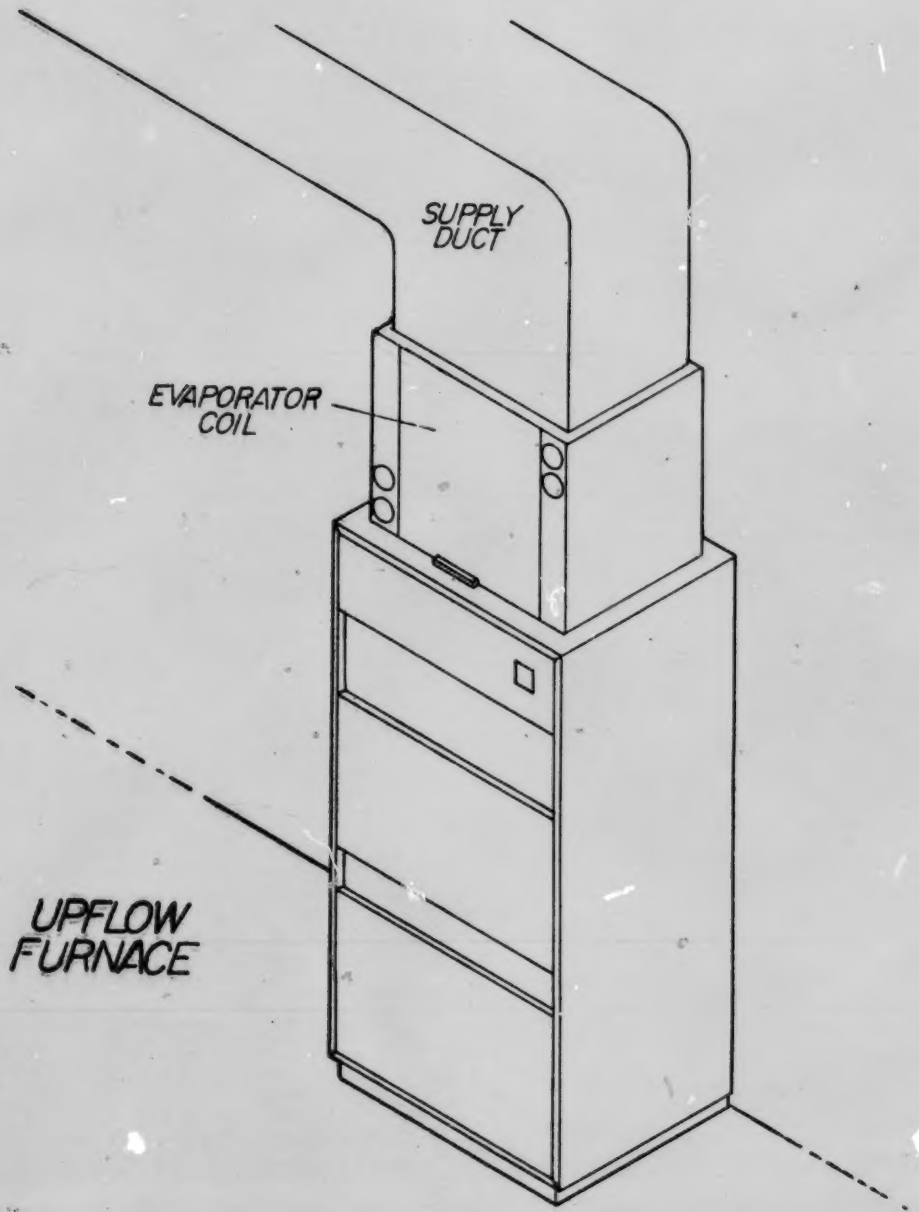


FIGURE E

PROCEDURES:

1. List all the materials needed to complete the drain described in Assignment Sheet AC-13b.

2. Secure materials needed to pipe this drain.

3. Select a upflow gas furnace with evaporator coil and run drain line.

PROCEDURES:

1. List all the materials needed to pump the condensate from a coil that is located below the natural ground level. (See Figure F).
2. Secure materials needed for the installation.
3. Have the instructor assign you an air conditioning unit and install the pump drain system.
4. Check the system by pouring water into the pump reservoir.

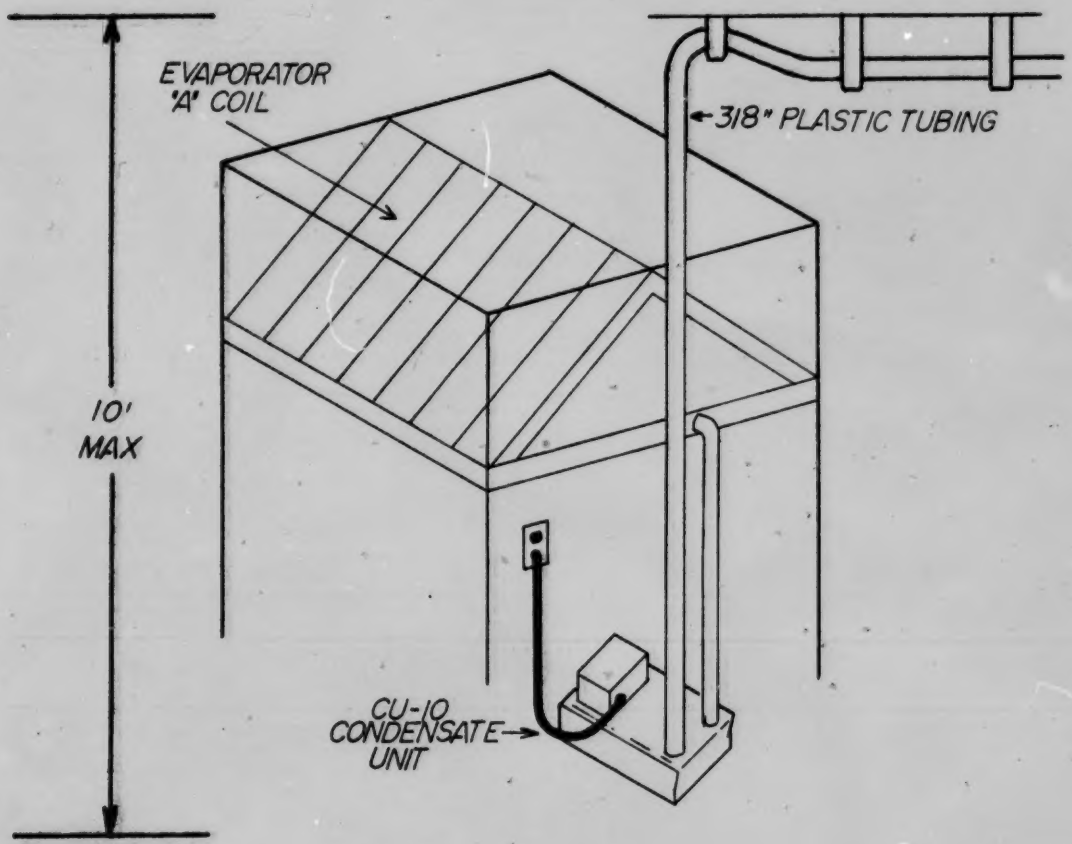


FIGURE F

MAJOR BLOCK Air Conditioning **NAME** _____

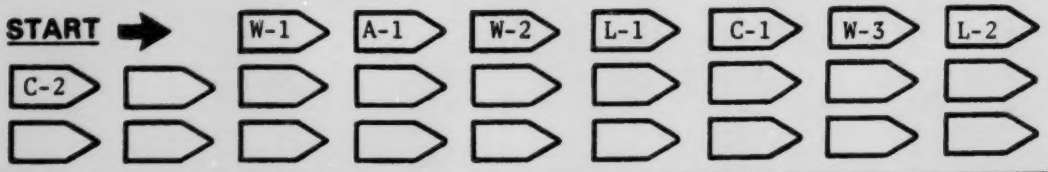
TASK System and Installation

UNIT Installing Package Unit (Residential and Mobile Home) **TIME (est.)** _____ **(act.)** _____

UNIT NO. AC-14

OBJECTIVE(S)

Install a package cooling system for residential and mobile home.



WRITTEN ASSIGNMENT(S)

- **W-1** Text Assignment AC-14a
- **W-2** Information Sheet AC-14a
- **W-3** Information Sheet AC-14b
- **W-4**
- **W-5**
- **W-6**
- **W-7**

AUDIOVISUAL(S)

- **A-1** Slide Set AC-14a
- **A-2**
- **A-3**
- **A-4**
- **A-5**
- **A-6**
- **A-7**

LABORATORY ASSIGNMENT(S)

- **L-1** Job Sheet AC-14a
- **L-2** Job Sheet AC-14b
- **L-3**
- **L-4**
- **L-5**
- **L-6**
- **L-7**
- **L-8**
- **L-9**

CHECKPOINT(S)

- **C-1** Instructor Check
- **C-2** Instructor Check
- **C-3**
- **C-4**
- **C-5**
- **C-6**
- **C-7**
- **C-8**
- **C-9**

Residential Units

Packaged cooling systems are units in which the complete refrigeration cycle, air-handling equipment and controls are located in the same cabinet. These units may be "free-blowing," installed with a duct system for air distribution, or they can be connected to an existing warm air duct system. Packaged units are available with either water-cooled or air-cooled condensers; however, air-cooled is the most common.

Packaged units are designed to meet many different residential installation requirements. For example, the units can be installed in the attic or crawl space, through the wall, suspended from the ceiling, placed on a roof, or on a concrete slab next to the basement.

Most units discharge cool air to the conditioned space through the top section of the front face and removes the warm air back through the front bottom section (see Figure A). Not all units are designed this way, some have the discharge and return air side by side.

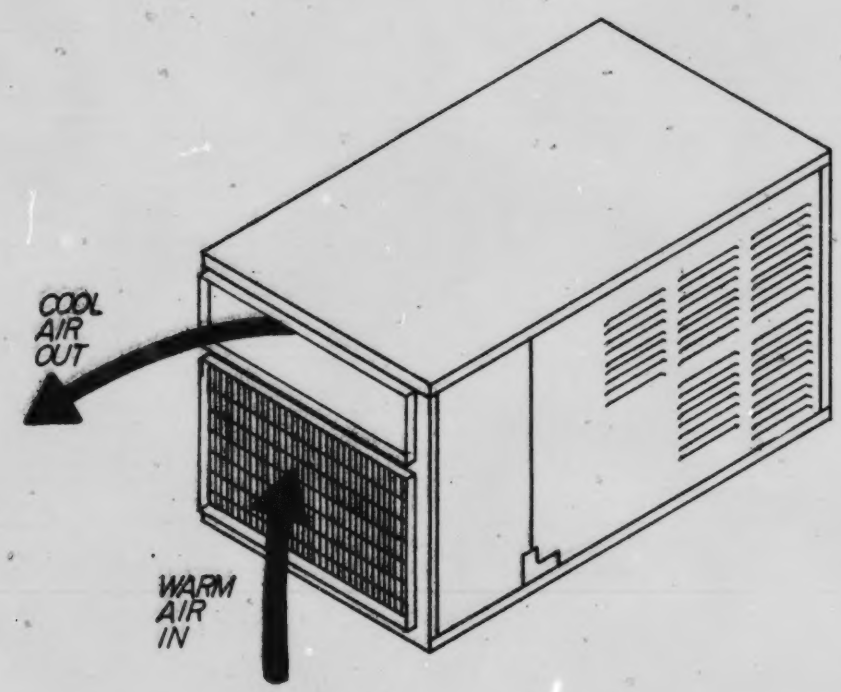


FIGURE A

Packaged Cooling Unit

1. Observe the typical packaged unit installation in Figure B and note the following areas.

   a. flashing
   b. flexible duct connection
   c. clearances for air and service
   d. disconnect
   e. thermostat
   f. foundation
   g. condensate drain

2. Have the instructor assign you a unit for installation.

3. Install the unit in accordance with the manufacturers specifications and Figure B.

4. Check with the instructor upon completion of job.

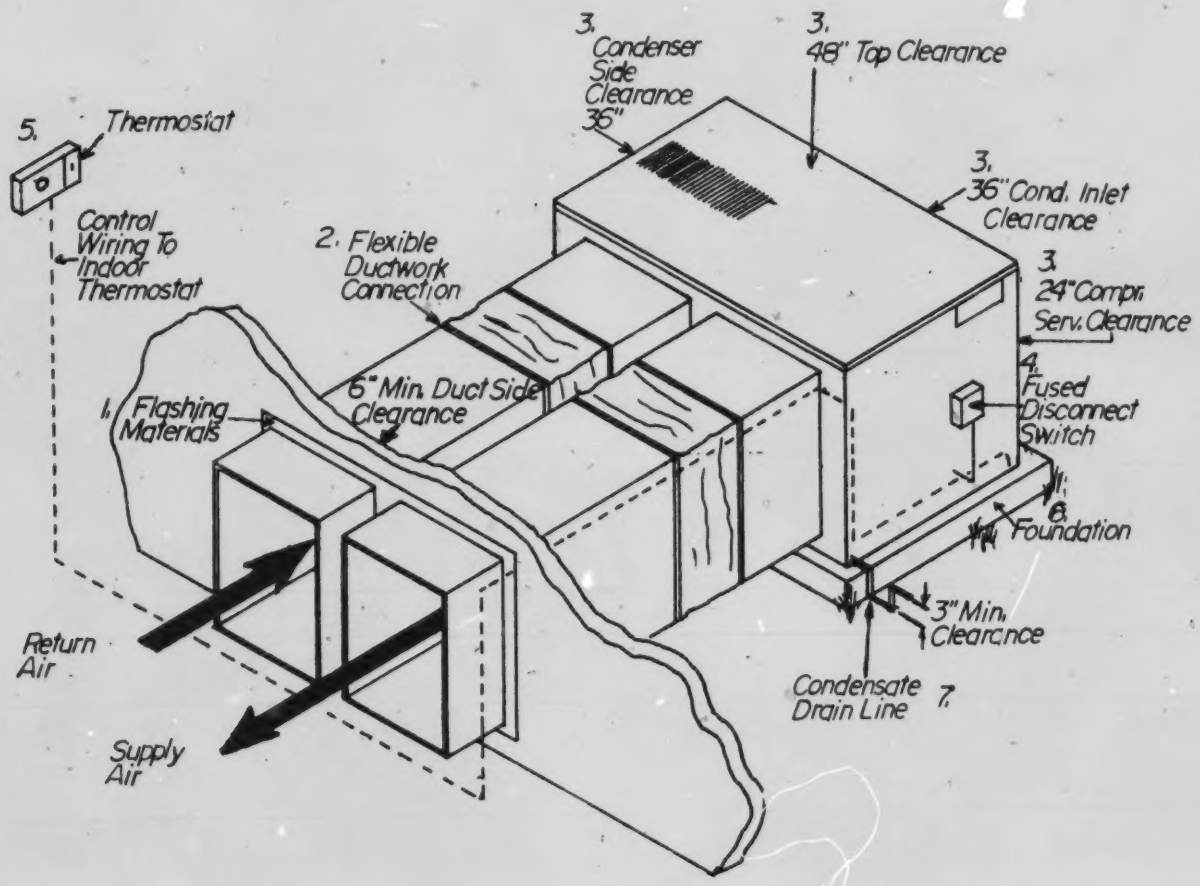


FIGURE B

Packaged Unit Installation for Residential

Package Mobile Home Units

The Package Mobile Home Units are also designed for outdoor installation requiring only line and control voltage electrical connections. The supply and return indoor air duct connections are made to the front of the unit. The unit is designed to be installed with the manufacturer's approved duct kit. The two flesible supply ducts should be connected near the center of the mobile home, with a minimum distance of 12 inches from the edge of an existing register, and equally spaced apart.

In most instances, the air registers supplied with the mobile home are intended for heating purposes and may be poor in design for cooling. These registers spread the air out at floor level and do not allow the heavier cooled air to reach a normal height (about 6 feet) for air conditioning. Proper registers should be used with a minimum of eight 4" x 10" registers for two and one half tons of air conditioning and ten 4" x 10" registers for three tons.

The return air floor register should be so located to draw from a central area of the home, preferably in the hallway. Under no circumstances should a unit be operated without return air filters.

For satisfactory operation, provisions must be made for blocking off the air distribution through the existing mobile home furnace during the summer season and through the air conditioner during the winter season.

Selection of Site:

The unit must be located where adequate outdoor air is available. The condenser fan is the direct-driven propeller type and is not intended to be used with ducting.

Locate the discharge side of the unit at least 3 ft from any wall or obstruction. For adequate inlet air, maintain a minimum of 1 ft. between air inlet side and any wall or obstruction.

DO NOT PLACE THE UNIT WHERE CONDENSER AIR RECIRCULATION MAY OCCUR.

Just prior to installation remove metal banding from carton and base skid. Examine unit for shipping damage and if damage is evident, file a claim with the transportation agency.

Using the previous information, text, manufacturer's installation manual, and the following illustrations (Figures C, D, E), install the mobile home package unit specified by the instructor.

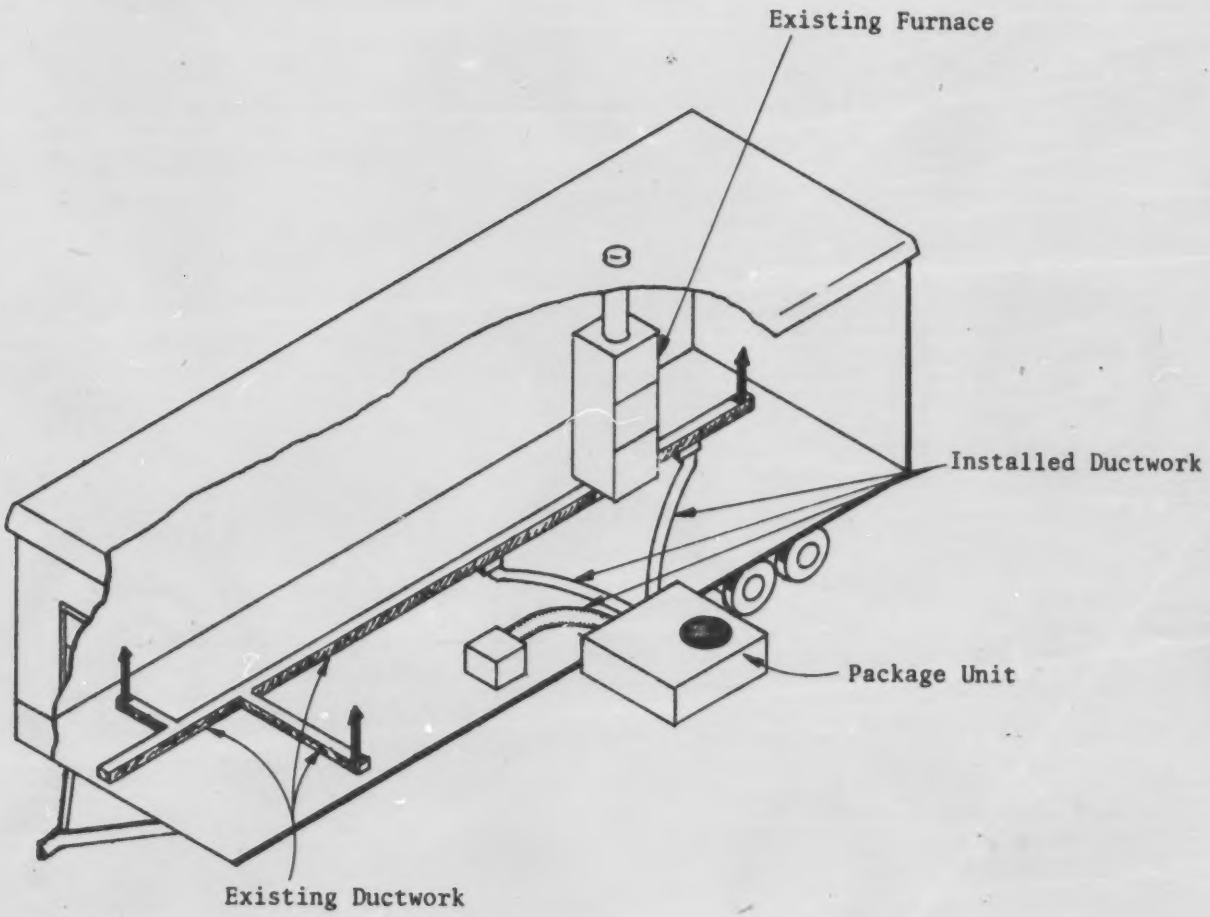


FIGURE C

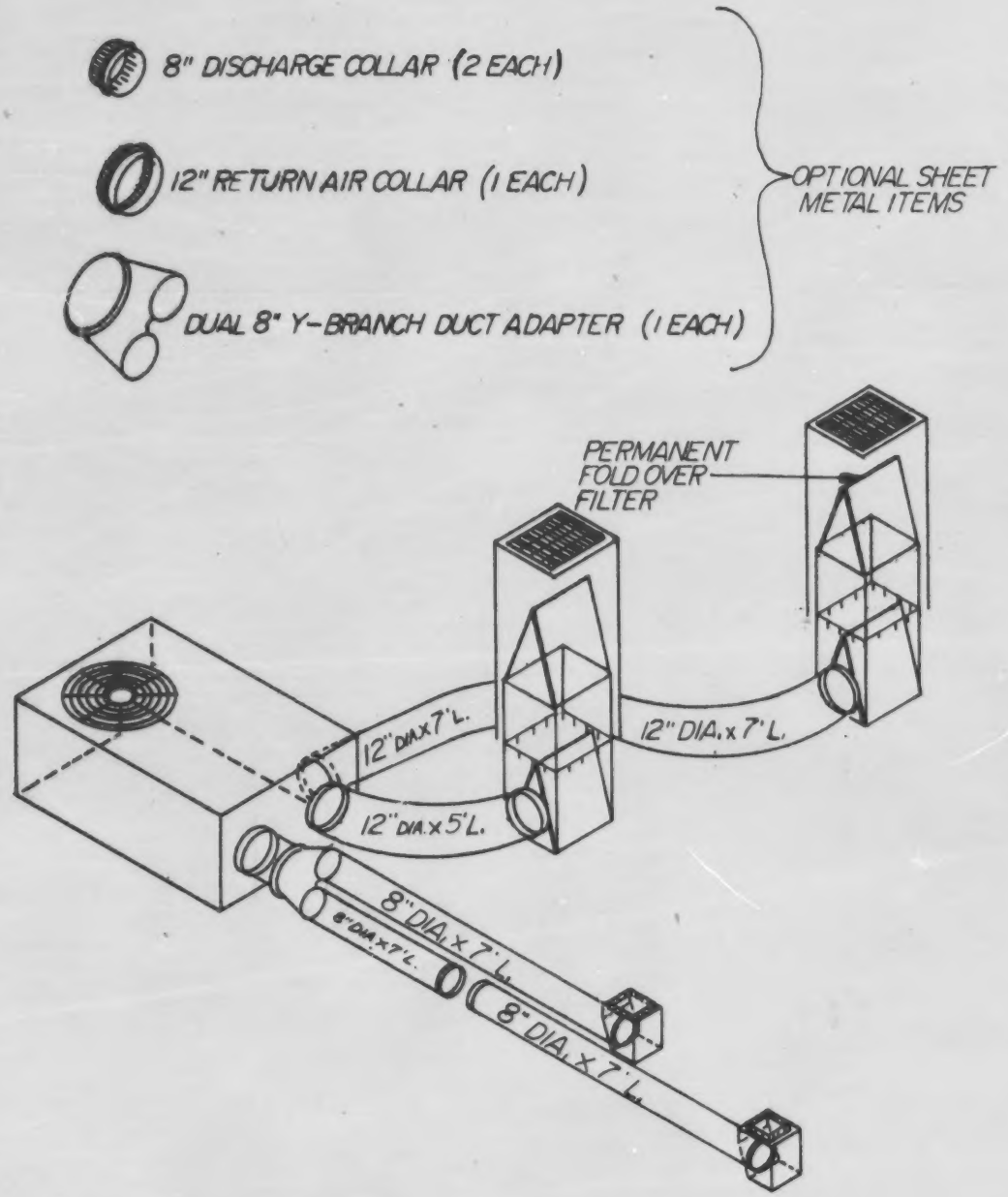
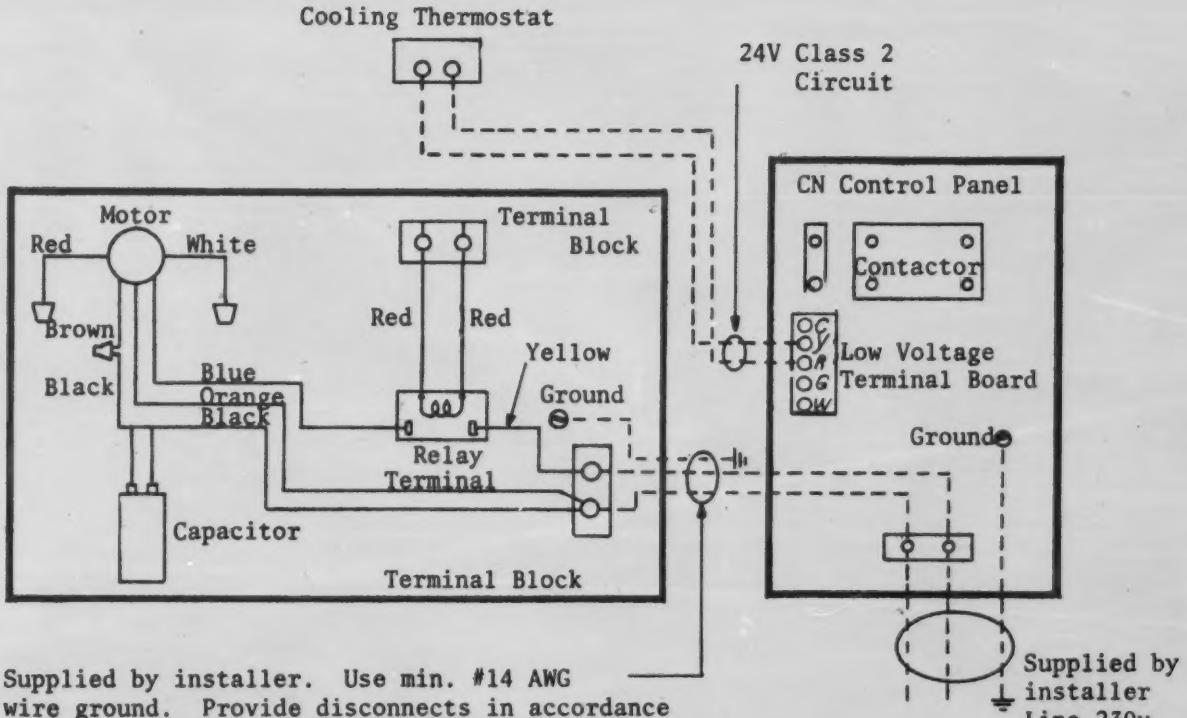

8" DISCHARGE COLLAR (2 EACH)
12" RETURN AIR COLLAR (1 EACH)
DUAL 8" Y-BRANCH DUCT ADAPTER (1 EACH)
OPTIONAL SHEET METAL ITEMS
PERMANENT FOLD OVER FILTER
12" DIA. x 7' L.
12" DIA. x 7' L.
12" DIA. x 5' L.
8" DIA. x 7' L.
8" DIA. x 7' L.
8" DIA. x 7' L.

FIGURE D



Supplied by installer. Use min. #14 AWG wire ground. Provide disconnects in accordance with the National Electric Code or equivalent. Do not connect to the neutral of a 230v, single phase, 3 wire system. Conductors over 25 ft. long shall have the current carrying capacity of the branch circuit conductors. Conductors less than 25 ft. long shall have a current capacity of one third the branch circuit conductors.

FIGURE E

Wiring Diagram for Mobile Home Package Unit

MAJOR BLOCK Air Conditioning **NAME** _____

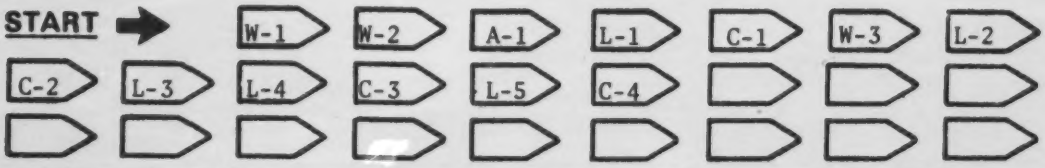
TASK System and Installation

UNIT Installing Split System **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-15

OBJECTIVE(S)

Install and wire a split system cooling unit.



WRITTEN ASSIGNMENT(S)

W-1 Information Sheet AC-15a
W-2 Text Assignment AC-15a
W-3 Assignment Sheet AC-15a
W-4 _____
W-5 _____
W-6 _____
W-7 _____

AUDIOVISUAL(S)

A-1 Slide Set AC-15a
A-2 _____
A-3 _____
A-4 _____
A-5 _____
A-6 _____
A-7 _____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet AC-15a
L-2 Job Sheet AC-15b
L-3 Job Sheet AC-15c
L-4 Job Sheet AC-15d
L-5 Job Sheet AC-15e
L-6 _____
L-7 _____
L-8 _____
L-9 _____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 Instructor Check
C-5 _____
C-6 _____
C-7 _____
C-8 _____
C-9 _____

Installing Split System

The term split-system (or remote), as the name implies, consists of two parts. In most cases, the "split" divides the system into an indoor cooling component (fan coil section) and an outdoor condensing section. The two are connected by refrigerant tubing and electrical controls. Condensing units, with a wide variety of air handlers and evaporator coils are designed for use in residential and commercial type buildings.

After having made allowance for the zoning ordinance, care should be exercised to not locate the condenser-compressor unit immediately adjacent to sleeping areas or in corners where operating noise can be amplified. Select a location as reasonably close to the indoor air handler as possible, avoiding any long refrigeration line runs. Position the condenser unit in such a way that the hot condenser air will be directed away from any roof overhang, thereby avoiding any unnecessary noise.

Refrigerant lines can be either hard or soft copper tubing. If hard copper tubing is used, extra precaution should be exercised to provide an internally clean and dry system. All copper to copper joints made on the refrigerant lines should be made with silver-solder or equivalent brazing material. Do not use soft solder. Soft, pre-charged tubing is available in various lengths and can be used with a minimum amount of risk and labor.

The instructor will assign an outside condenser-compressor unit to be installed at ground level. Use the following diagram and procedures for that installation.

1. Select a location for the unit. (Remember clearance and distance from evaporator.)
2. Prepare foundation base for the unit.
3. Hook up refrigeration lines.
4. Connect the necessary wiring.
5. Test the refrigerant cnarge.

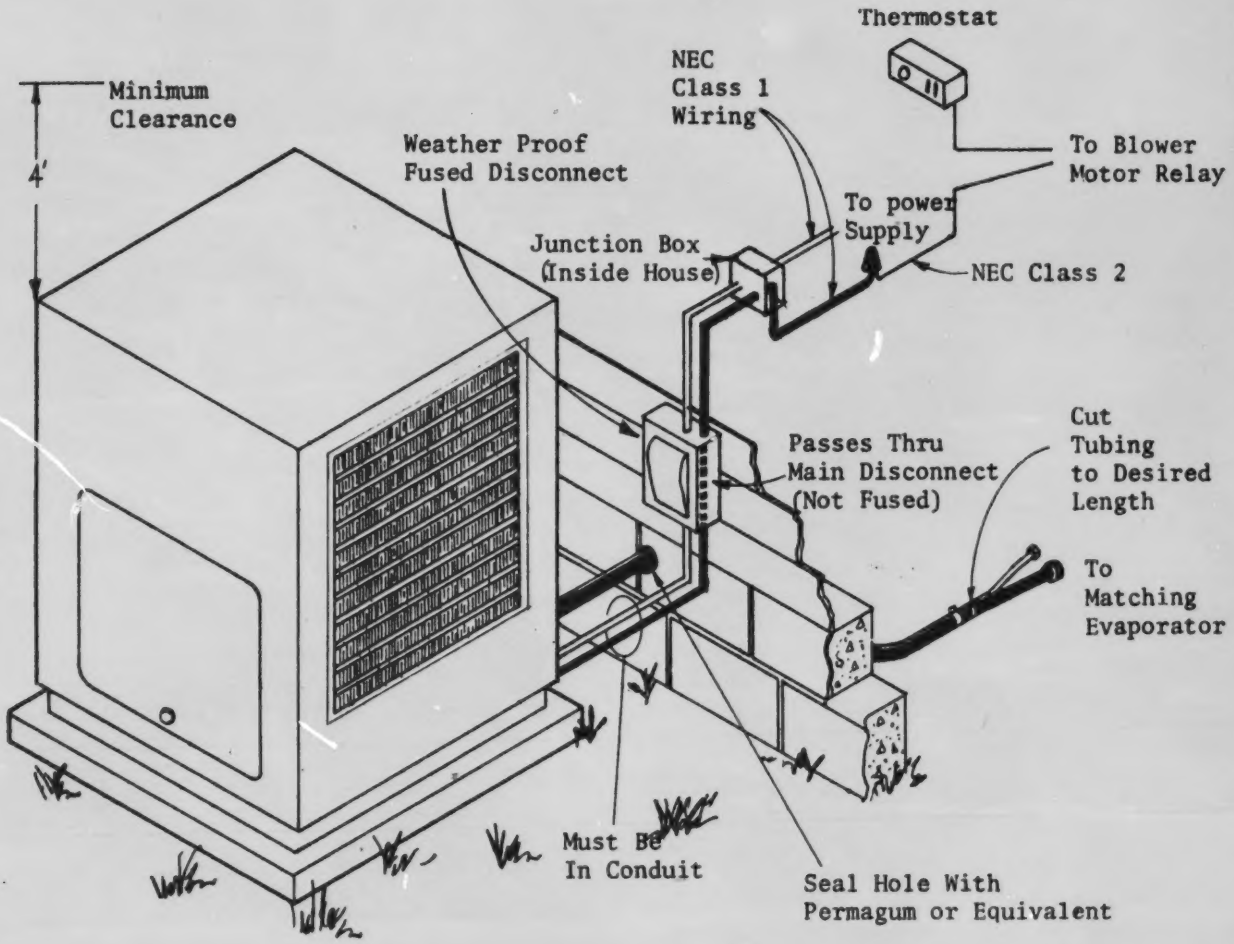


FIGURE A

There are several different types or positions in which the basic unit may be installed into a residence. Each type on a split system would be tied into the outside condenser for cooling of the inside temperature. In Figure B, identify each figure as to type and position.

	Type	Position
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____

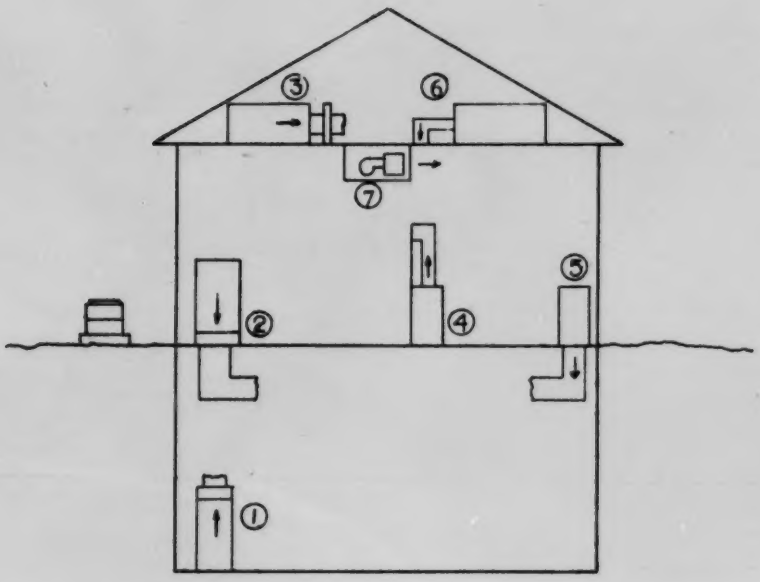


FIGURE B

After observing Assignment Sheet AC-15b and the slides, take a blower section and install it like #7 in the picture on the Assignment Sheet. The installation will include all control wiring and proper line voltage.

The instructor will assign a split system on which the student should measure the distance between the evaporator-blower and the outside unit (the route the refrigerant lines would run), keeping in mind that the lines cannot make close turns.

Secure a tubing set the correct length and run the lines. Connect both ends. Perform the leak test and evacuation procedures on the unit.

Wire up the total system including line voltage and control using manufacturer instruction and wiring diagram.

Install gauges on system and amp-meter and start system up. Check charge and amp. Wait 20 - 30 minutes and check again.

MAJOR BLOCK Air Conditioning **NAME** _____

TASK System and Installation

UNIT Installing add-on Split System **TIME (est.)** _____ **(act.)** _____

UNIT NO. AC-16

OBJECTIVE(S)

Install and wire an add-on split system.

START → W-1 → A-1 → W-2 → W-3 → L-1 → C-1 → W-4 → L-2 → C-2 → L-3 → C-3 → L-4 → L-5 → C-5

WRITTEN ASSIGNMENT(S)

W-1	Text Assignment AC-16a
W-2	Information Sheet AC-16a
W-3	Information Sheet AC-16b
W-4	Information Sheet AC-16c
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set AC-16a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet AC-16a
L-2	Job Sheet AC-16b
L-3	Job Sheet AC-16c
L-4	Job Sheet AC-16d
L-5	Job Sheet AC-16e
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	Instructor Check
C-5	
C-6	
C-7	
C-8	
C-9	

The term split-system (or remote) as the name implies, consists of two parts. An add-on split system has some similarity to a split cooling system. The greatest difference is in the indoor coil and the control wiring. The indoor coil should match up to the type of installation of the existing indoor unit (upflow, downflow, horizontal), within the available space. The fan also had to handle enough air for the coil and must overcome the resistance the coil offers to the flow of air. The control wiring must take care of the heating and cooling mode. Caution must be exercised not to locate the condenser-compressor unit immediately adjacent to sleeping areas or in corners where operating noise can be amplified. Select a location as reasonably close to the indoor air handler as possible, thus avoiding any long refrigeration line runs. Position the condenser unit in such a way that the hot condenser air will be directed away from any roof overhang, thereby avoiding any unnecessary noise.

Refrigerant lines can be either hard-drawn or soft copper tubing. If you use hard-drawn tubing, extra precaution should be exercised to provide an internally clean and dry system. All copper to copper joints made on the refrigerant lines should be made with silver-solder or equivalent brazing material. Do not use soft solder. Soft drawn, pre-charged tubing is available in various lengths and can be used with a minimum amount of risk and labor.

The student should study the illustration below. It, and the slide/tape presentation will give an overview of how the outside unit on split system should be installed.

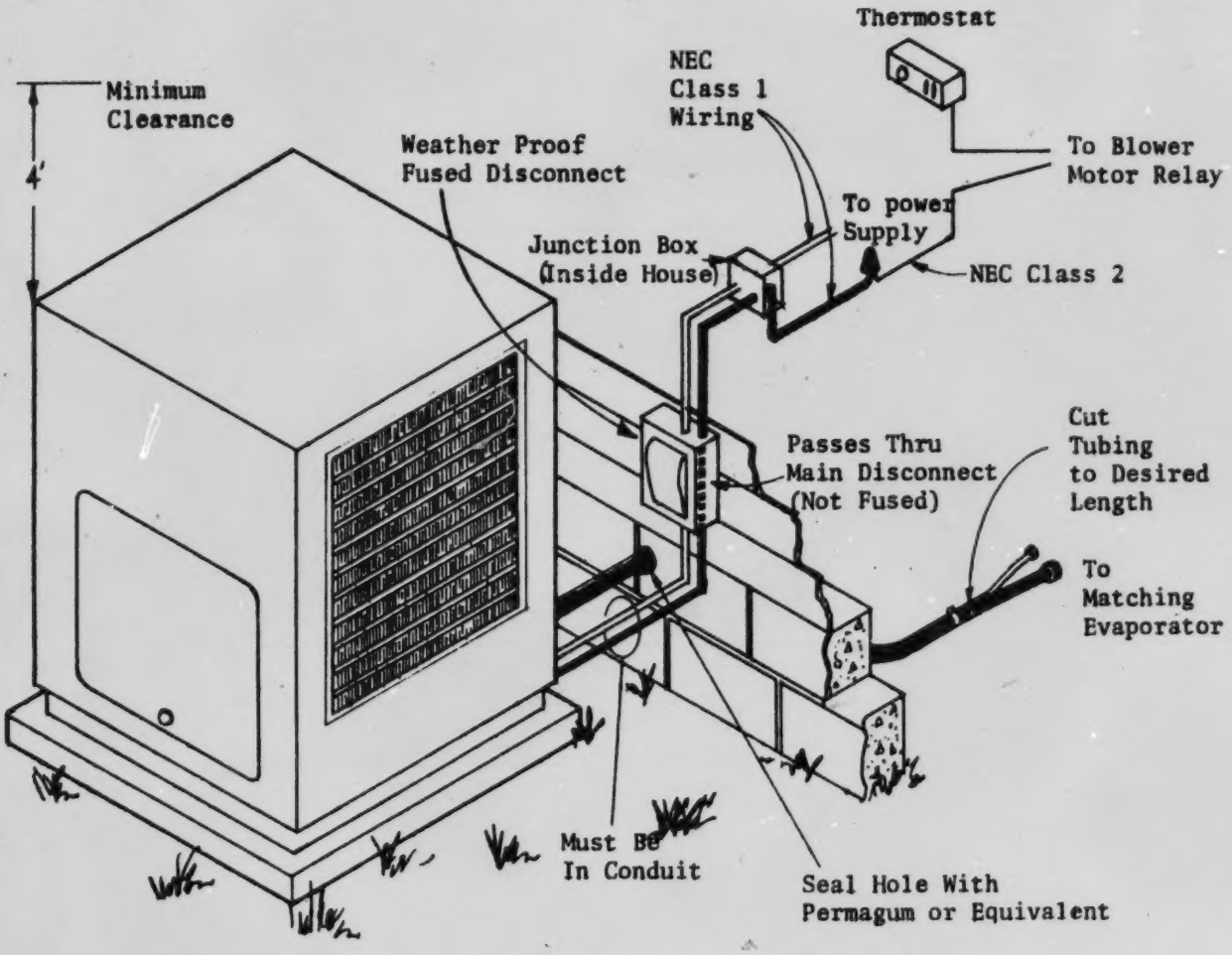
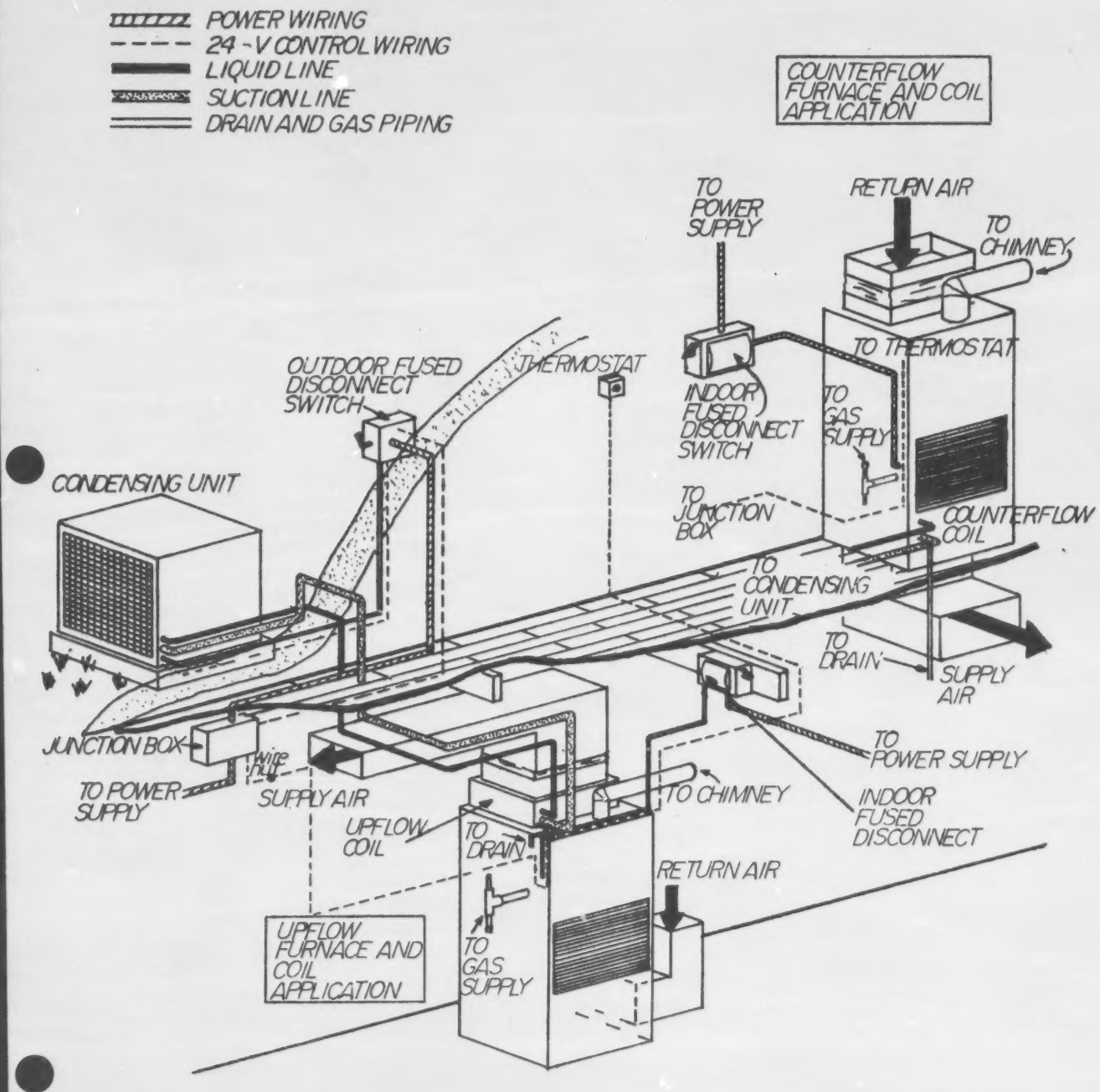


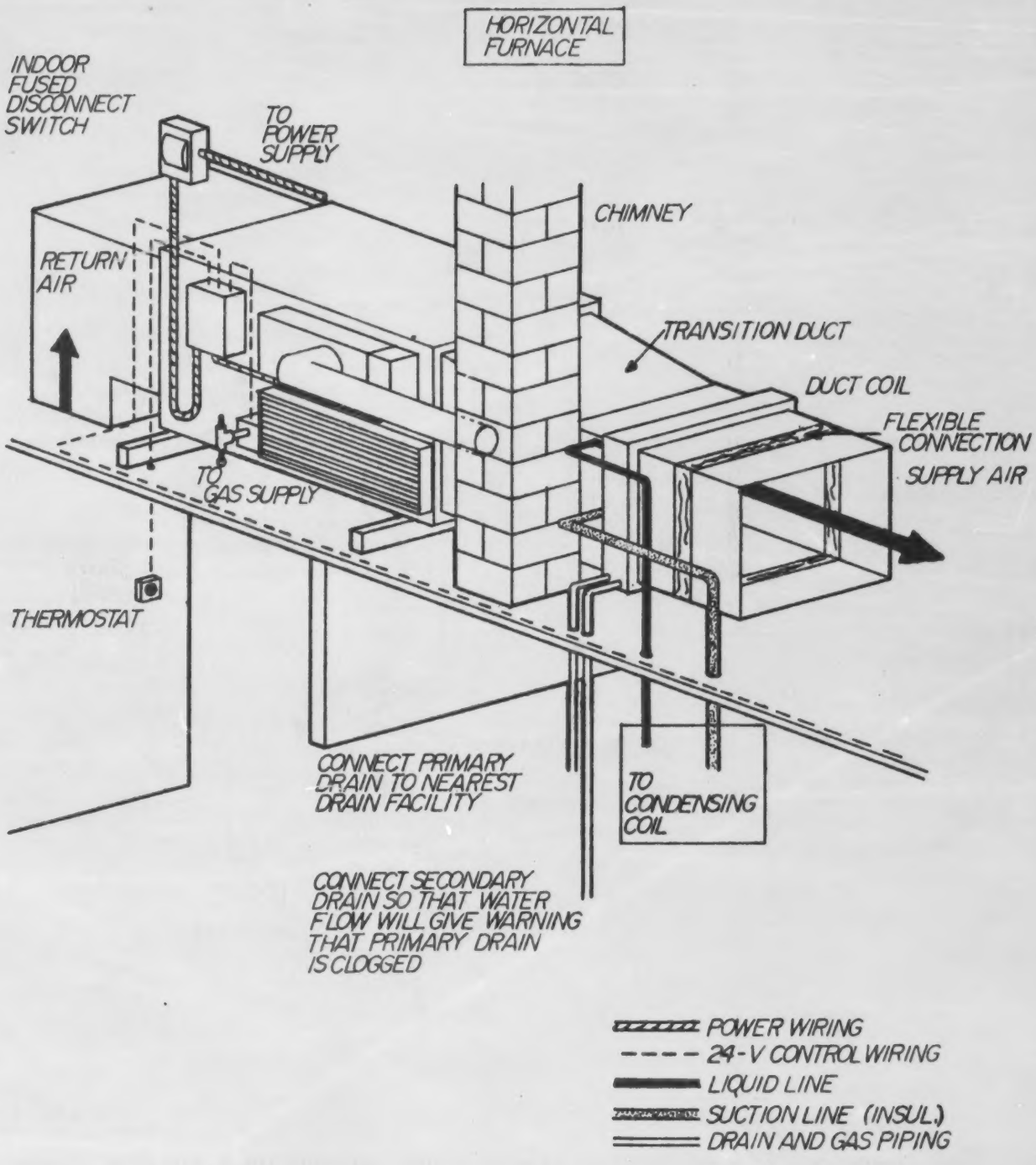
FIGURE A

As a practical exercise reinforcing the knowledge gained through this and other units, report to the instructor and ask that an outside condenser-compressor unit (ground level) be assigned for installation. Use as a guide any notes made while viewing the slide/tape presentation AC-16a or reading the Text Assignment AC-16a or Information Sheet AC-16a.

Observe all the notes made in this picture. This along with the slides should give you an overall picture of how the indoor coils should be installed.

The student should study the illustration below. It, and the slide/tape presentation will give an overview of how the indoor coils should be installed.



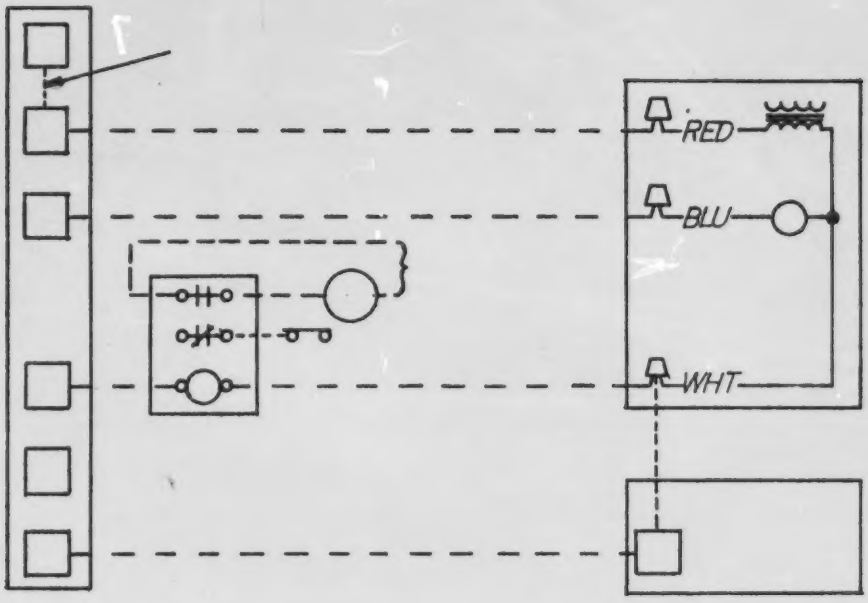

HORIZONTAL FURNACE
INDOOR FUSED DISCONNECT SWITCH
TO POWER SUPPLY
CHIMNEY
RETURN AIR
TRANSITION DUCT
DUCT COIL
FLEXIBLE CONNECTION
SUPPLY AIR
TO GAS SUPPLY
THERMOSTAT
CONNECT PRIMARY DRAIN TO NEAREST DRAIN FACILITY
TO CONDENSING COIL
CONNECT SECONDARY DRAIN SO THAT WATER FLOW WILL GIVE WARNING THAT PRIMARY DRAIN IS CLOGGED
POWER WIRING
24-V CONTROL WIRING
LIQUID LINE
SUCTION LINE (INSUL.)
DRAIN AND GAS PIPING

Report to the instructor and ask to be assigned to a unit where an upflow coil may be installed. Use as a guide any notes made while viewing the slide/tape presentation and appropriate reading assignments.

Measure the distance between the evaporator-coil and the outside unit (the route the refrigerant lines would run), keeping in mind that the lines cannot make close turns.

Next, obtain from the supply room or the instructor a tubing set the correct length and run these lines. Connect both ends.

Wire up the total system including line voltage and control using the manufacturer's instructions and the wiring diagram below:



Install gauges on the system. Check the charge. Install amp-meter and check amps. Wait 20 to 30 minutes and check again.

MAJOR BLOCK AIR CONDITIONING NAME _____

TASK Troubleshoot and Service

UNIT Troubleshooting Compressor Burnout TIME (est.) _____ (act.) _____

UNIT NO AC-17

OBJECTIVE(S)

Troubleshoot and change a compressor burnout.

START → W-1 W-2 C-1 W-3 C-2 A-1 L-1
L-2 C-3

WRITTEN ASSIGNMENT(S)

W-1 Information Sheet AC-17a
W-2 Text Assignment AC-17a
W-3 Information Sheet AC-17b
W-4
W-5
W-6
W-7

AUDIOVISUAL(S)

A-1 Slide Set AC-17a
A-2
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet AC-17a
L-2 Job Sheet AC-17b
L-3
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4
C-5
C-6
C-7
C-8
C-9

The compressor which is one of the major components of the air conditioning cycle may become inoperative due to burned out windings or mechanical failures. Without a properly functioning compressor the system cannot sufficiently cool. Very often the compressor is called the "HEART" of the air conditioning system because while running, it circulates the freon through the system.

The compressor, like many other man made devices can become inefficient due to malfunctions or electrical problems. For example, liquid floodback, lack of proper lubrication and overloaded conditions are problems which rate high on the list as causes of mechanical failures. Problems such as low voltage, lighting, malfunctioning starting devices and inefficient wiring may cause most of the electrical problems and motor burnouts.

In any case, all major mechanical and electrical problems may require a compressor change out. Before the service technician replaces the motor compressor, it is necessary to perform all possible mechanical and electrical tests. In many cases these tests, if performed correctly, may eliminate an unnecessary compressor change out. Following are some of the mechanical failures which occur within the motor compressor: broken reed valves, broken piston rods, scored piston walls, bearings, etc. The electrical problems usually occur because of grounded windings, shorted windings, defective motor terminals open or defective overload, loose wires on motor terminals, etc. Excessive discharge pressure and temperature may also shorten the life of the motor-compressor.

A good service technician will not remove a motor compressor unless all possible tests are made before removal. The causes of compressor failures are many. Failures may be avoided by expert and periodic servicing. Some motor compressors, however, may fail without a cause being apparent. If a motor compressor is defective electrically or mechanically it should be removed and a new one replaced using good work procedures and careful workmanship.

CLEAN OUT PROCEDURES

When it has been established that a burnout has occurred, follow the manufacturer's cleanout procedure, if availalbe. If not, the following step by step procedure is suggested:

1. Discharge the refrigerant to the outside, CAUTION: The refrigerant may contain acids.
2. Remove the burned out compressor.
3. Flush out the system with R-11 or R-12 refrigerant.
4. Install new liquid and section line filter drier.
5. Install new compressor and check oil level.
6. Pressurize system with freon.
7. Test for freon leaks.
8. Evacuate the system from 500 to 1000 microns with a 2-stage vacuum pump. (Do not use the motor-compressor to evacuate the system).
9. Break the vacuum with freon vapor.
10. Repeat vacuum process for two or three times.
11. Charge system with correct charge of freon.
12. Check high or low pressure.
13. Check air temperature across evaporator.
14. Check voltage.
15. Check amperes.
16. Check overall performance for floodback, noise, etc.
17. Check system performance after 12 hours of operation, if possible.

The steps listed should serve as a guideline for a compressor removal and the system cleanout after a burnout has occured.

The service technician should follow necessary steps to determine if a compressor is defective to the extent that removal is required. The following are the procedures for determining compressor burnout. Ask your instructor to assign a unit on which this activity can be performed.

First, it is a good practice for the technician to test the motor compressor electrically starting with the power supply.

1. Power supply
   a. Check for tripped breaker or blown fuse.
   b. Check voltage at line side of contactor.
   c. Check for contactor pull in.
   d. Check voltage at compressor terminals.

2. Control circuit

   a. Check voltage at contacor coil.
   b. Check all safety controls and thermostat.

3. Remove power wiring from motor terminals and check each terminal for ground and check across each terminal for continuity. The following is a typical diagram of motor windings:

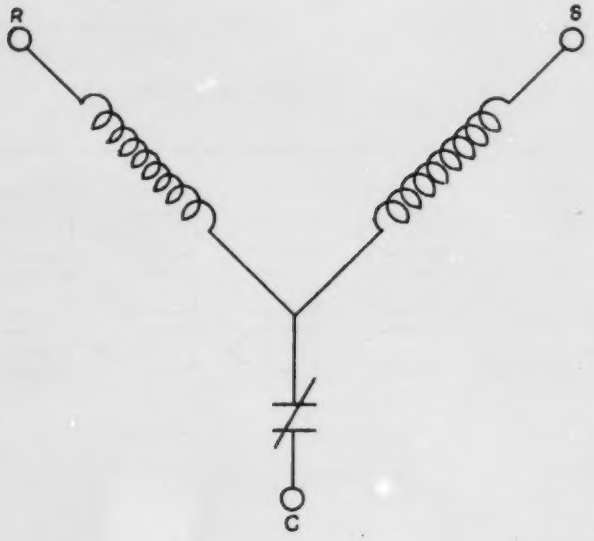


FIGURE A

A. Check compressor terminals R, S and C to shell for grounded motor.
B. Check continuity between S and R terminals.
C. Check continuity between C and S terminals.
D. Check continuity between C and R terminals.
E. If not grounded, and there is continuity between all terminals the motor compressor may be considered operational.
F. If no continuity exist between C and S and C and R, but there is continuity between R and S the internal overload is open.
G. If no continuity exists between R and S, one or both motor windings have failed.

4. Steps for starting the compressor when the internal overload is open:

   a. Disconnect motor compressor from the contactor.
   b. Let compressor cool off to the extent that the overload will reset. (If overload does not reset, it may be defective).

5. If the compressor still does not run after the overload closes, the following may be checked:

   a. starting components
   b. low voltage
   c. run capacitor (P.S.C. Motor)

6. If compressor runs, check possible causes for internal overload tripout.

   a. low freon charge or restriction
   b. faulty condensor fan motor or restricted condenser
   c. Check for high compressor running amperes (F.L.A.) if higher than normal, check for cause.

It is also suggested that a compressor may be tested electrically by the resistance method. (Be sure to remove the power wiring from the motor terminals). By using the diagram hereon, one may make the following tests:

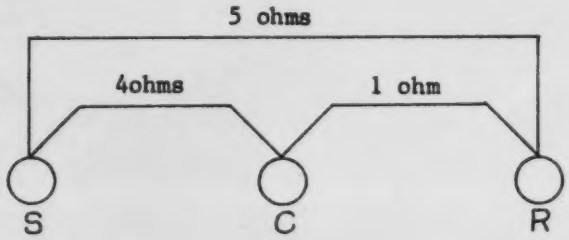


FIGURE B

NOTE: C and R lowest reading
C and S second highest reading
R and S highest reading

A readable low resistance should be found if the motor windings are good. Typical run winding resistance is between 1/2 to 2 ohms. Single phase motors usually have a common to start winding resistance 3 to 6 times greater than the common to run winding. As noted on the diagram, C and R plus C and S is equal to S and R. (1 + 4 = 5 ohms). This would indicate that the motor compressor windings are good. If the motor windings are short circuited the resistance will go to zero ohms on the meter scale and would indicate possible burned out windings. If a resistance reading occurs between the motor terminals and the shell, the motor windings would be burned, or grounded.

Motor compressors are replaced due to various mechanical failures. A suggested list is as follows:

a. check high and low side pressures while running
b. make a vacuum efficient test, if possible
c. check oil level
d. make an oil acid test, if an odor occurs
e. if the compressor burns, the bearings may be binding due to low oil level, or "washout" due to excessive liquid refrigerant in the oil

A. Your instructor will assign a unit on which the motor-compressor can be replaced (make sure all lines and components have been cleaned out before replacing).

1. Locate replacement compressor.
2. Check name plate data to identify the correct compressor prior to installing.
3. Check frame and mounting holes to make sure that measurements are correct.

B. Install replacement compressor.

1. Replace service valves and/or solder refrigerant lines to new compressor. (silver solder recommended)
2. Connect wiring to the motor-compressor terminals.
3. Connect all central circuits.
4. Replace mounting bolts at base of compressor (if spring mounted, do not over tighten).

C. Re-check all tubing connections, wiring and compressor counts for good workmanship. Make any corrections that may be necessary.

D. Install gauge and manifold set on compressor.

1. Pressurize system with freon to about 40 to 50 lbs. P.S.I.G. and test for freon leaks. (High pressure leaks may require more pressure).
2. If no leaks occur, release the freon pressure to zero lbs. P.S.I.G.

E. Consult your instructor for possible questions and evaluation at this point.

F. Obtain 2-state vacuum pump from the lab area, or tool room.

1. Connect vacuum pump.
2. Evacuate the system down to at least 1000 microns, 500 microns is preferable. (Triple evacuation process is recommended by most manufacturers to assure the system to be free of moisture and acids).
3. Charge the system with the proper flow according to manufacturer's specifications.

G. While the motor-compressor is running, check the running amperes (F.L.A.) line voltage at the contactor or motor terminals, high and low side pressures and any noise that may be abnormal.

H. After system has been in operation for approximately one hour, check and record the following:

1. Low side pressure _____ P.S.I.G.
2. High side pressure _____ P.S.I.G.
3. Temperature of suction line _____ F.

Inlet evaporator air temperature _____ F.

5. Outlet evaporator air temperature _____ F.
6. Temperature drop across evaporator _____ F.
7. Ambient temperature _____ F.
8. Condensing temperature _____ F.
9. Liquid line temperature _____ F.
10. Overall performance of system

Remarks: _____

_____

_____.

I. Obtain instructor for evaluation

1. Satisfactory _____.
2. Unsatisfactory _____.

MAJOR BLOCK AIR CONDITIONING **NAME** _____

TASK Troubleshooting and Servicing

UNIT Troubleshooting Fans and Fan Motors **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-18

OBJECTIVE(S)

Troubleshoot and repair or replace fans or fan motors.

START → W-1 → A-1 → C-1 → W-2 → L-1 → C-2 → L-2 → C-3

WRITTEN ASSIGNMENT(S)

W-1	Information Sheet AC-18a
W-2	Text Assignment AC-18a
W-3	
W-4	
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set AC-18a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet AC-18a
L-2	Job Sheet AC-18a
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

Electric motors are used in the air-conditioning field to drive the condenser and evaporator fans and the compressor. Manufacturers will use several different types of motors. The application of a specific motor depends on the job it has to do.

This information sheet will cover five of the most common types of single-phase motors and one three phase motor. Pay close attention to the illustrations and you should be able to determine, by inspection, the particular type of motor.

1. Shaded Pole Motor (Figure A)

In the shaded pole type of motor, the shading ring or pole creates out of phase field components to start the motor. The motor consists of a run winding and shading rings or poles. Once started, the shaded pole type runs as an induction motor. This motor has a very low starting torque, its speed varies with the load, and its running torque is fair. It is suitable for low starting loads, is quiet in operation, is relatively simple in design and is inexpensive. Its application is to drive blowers, small pumps, etc. Usually, these motors are less than one horsepower.

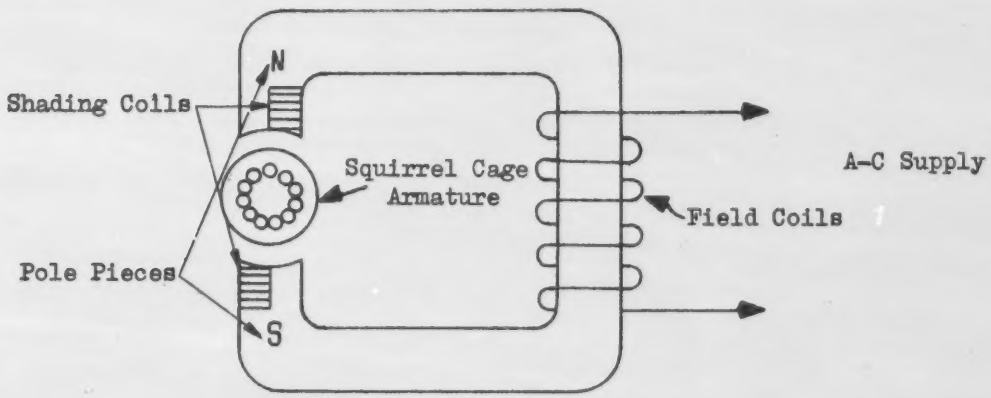


FIGURE A

THE SHADED POLE MOTOR

2. Split Phase Motor (Figure B)

The split phase motor uses a starting winding, which is open circuited by a centrifugal switch, after the motor has reached approximately three quarters of its operating speed. The components of this motor are: a run winding, start windings, and a switch. Most of these motors

can be reversed by changing the starting winding leads. Many of these motors will have permanently sealed bearings which cannot be lubricated. The split phase motor can be used for fans, blowers, and water pumps. This motor has a medium starting torque and cannot be used on high starting torque applications.

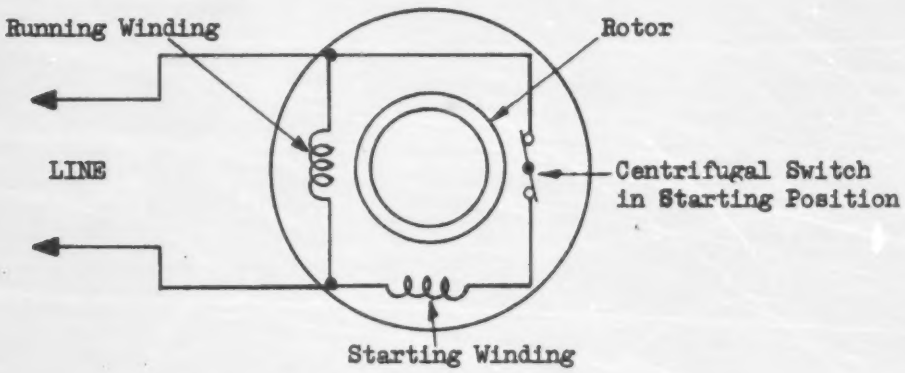


FIGURE B

SPLIT PHASE MOTOR

3. Capacitor Start Motor (Figure C)

The capacitor start motors are used where starting torques must be relatively high in relation to running torque. These motors feature

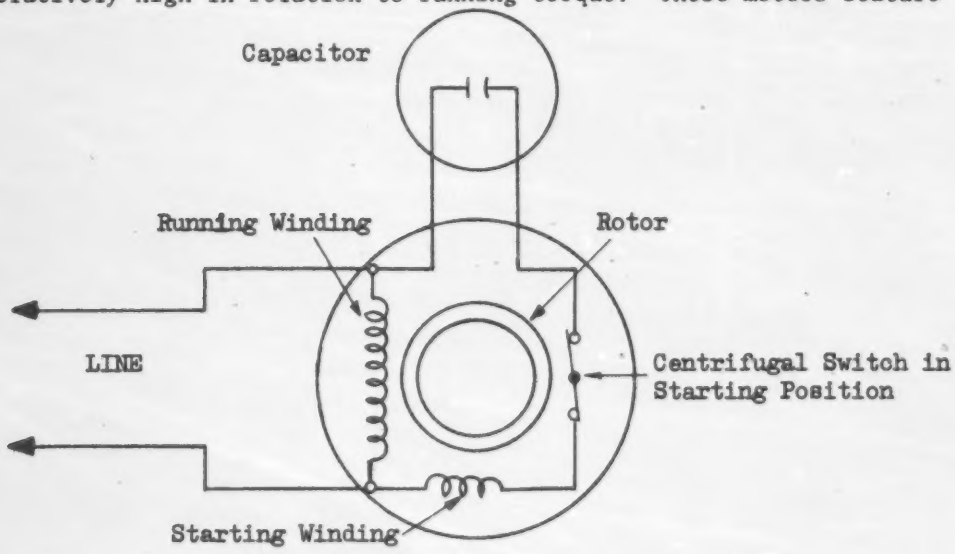


FIGURE C

CAPACITOR START MOTOR

a run winding, starting winding, start capacitor, and a centrifugal switch. The switch must disconnect the start winding and the start capacitor after reaching approximately 75% of its running speed. Capacitor start motors may be used on high and low starting torque applications such as, fan motors, pump motors, etc. Like the split phase motors, the capacitor start motor can be reversed in rotation and may have dual voltage capabilities.

4. Permanent Split Capacitor Motor (Figure D)

The PSC motor features a run capacitor which stays in the circuit during the motor operation. The run capacitor is connected to the run and start terminals and is sized according to the motor specifications. The purpose of the run capacitor is to make the motor more efficient by holding the voltage up across the windings therefore, reducing the amperes. The PSC motor has a low starting torque and is used mostly for fan or blower applications. The motor may also be used to drive the compressor on capillary tube systems. The PSC motor features a run and start winding and a run capacitor. These motors are simple in design, have less moving parts and are very easy to service.

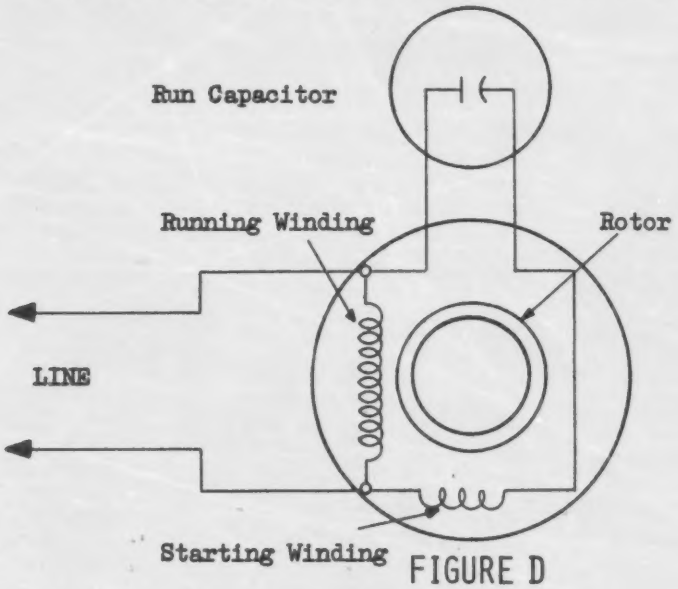


FIGURE D

PERMANENT SPLIT CAPACITOR

5. Capacitor Start/Run Motor (CSR) (Figure E)

The CSR motor may be described as a heavy duty PSC Motor. Both the starting and running torque requirements are high. The addition of a starting capacitor and a relay to the PSC motor changes it from a low to a high starting torque. Due to this high starting torque, they

can be used as compressor motors as well as fan and blower motors. During the start up of the CSR motor, the relay kicks the starting capacitor out of the circuit when the motor attains 75% of its speed. The start winding, however, is not removed from the circuit. The start capacitor's only purpose is to assist the motor in starting while the run capacitor increases the efficiency and performance of the motor while running at full speed. To identify a CSR motor one must look for a start and run capacitor and a relay or centrifugal switch. The motor also features a start and run winding.

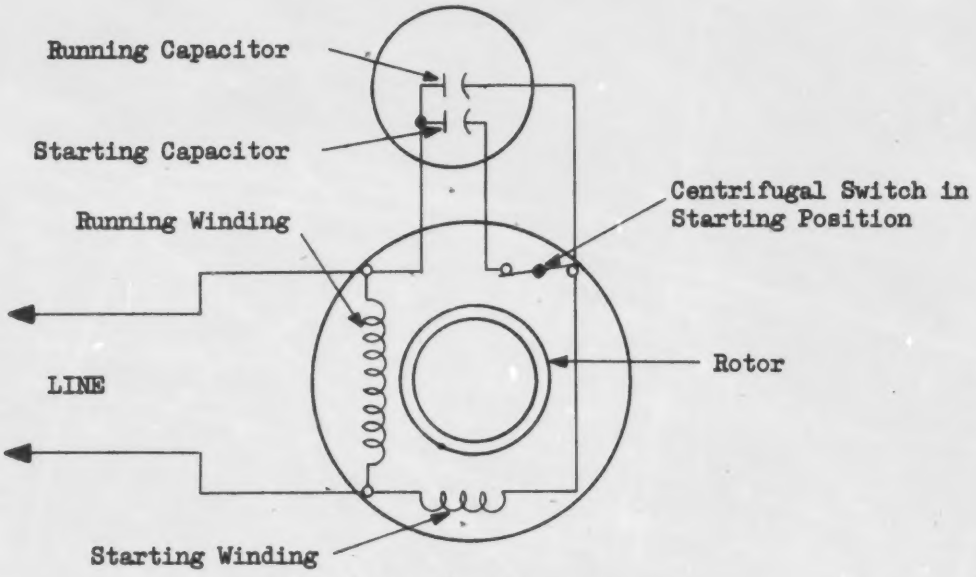


FIGURE E

CAPACITOR START/RUN MOTOR

6. The Three Phase Motor (Figure G)

The three phase motors do not feature any capacitors or relays. These motors have three windings, all of which are equal in resistance readings. They have good starting and running characteristics and high efficiency. Often the three phase motor features a 3, 6 or 9 motor lead application. When this is the case, note the wiring

data on the name plate for correct hookup. To reverse a three phase motor, only two of the three leads need to be changed. Because of the simpler mechanical design, three phase motors do not require repairs as often as the single phase type. Of course, three-phase voltage must be available to use this type of motor.

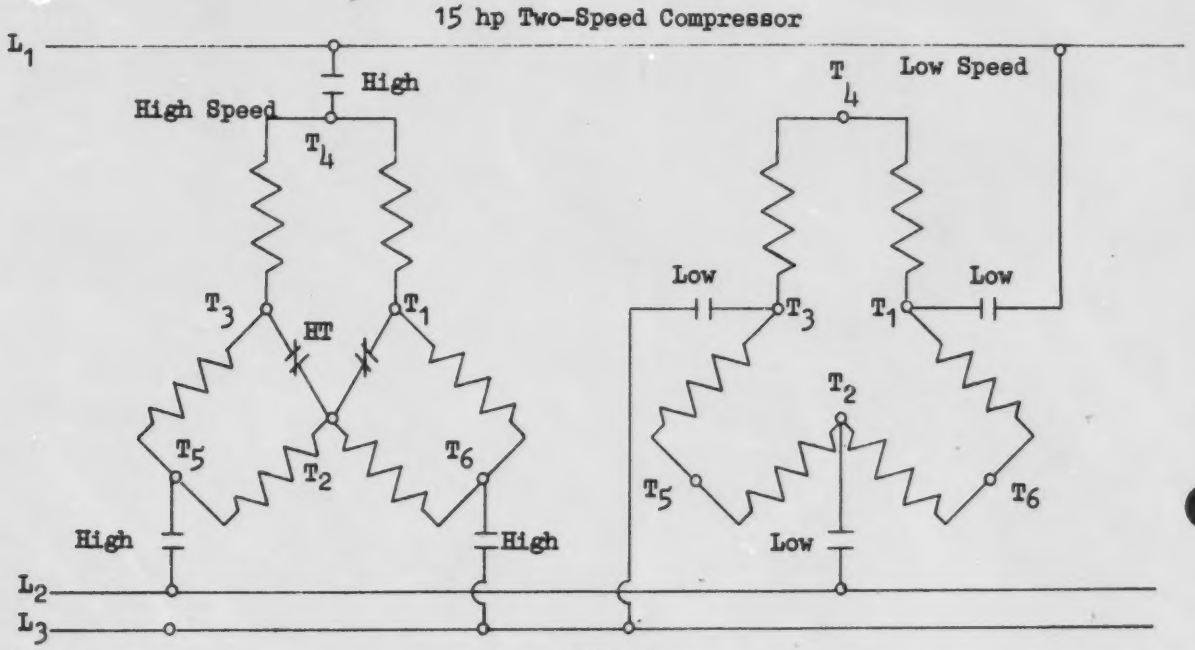


FIGURE F

THREE PHASE MOTOR

Test, Remove, and Replace Evaporator Fan Motor

1. Before removing the evaporator fan motor it is good practice to make the following tests:

   a. Make sure sufficient voltage is applied to the motor.

   b. Test all electrical connections leading to the motor.

   c. Test all starting components, if applicable.
      1. centrifugal switch or relay
      2. starting capacitor
      3. run capacitor (PSC or CSR motors)

   d. Make resistance test on the motor windings.

   e. Test for shorted or grounded windings.

   f. Test the motor shaft bearings. (Make sure shaft turns freely, also make sure shaft is not too loose in the bearings. Try to move shaft up and down or sideways.)

   g. Check for loose mounting bolts or loose connections.

   h. Check for loose fan blade, or out of balance blades.

   i. Check for loose motor and fan pulleys (if belt driven).

   j. Check for broken fan belt (if belt driven).

2. If the fan motor is defective, as the result of testing, use the following guideline for removal of motor.

   a. Make sure the electrical power is off.

   b. If direct drive, remove the fan cage assembly, if possible.
      1. remove the electrical wiring
      2. remove motor mounting bolts
      3. remove fan or blower
      4. remove fan motor

   c. If belt driven, only remove the fan motor.
      1. remove fan belt
      2. remove motor mounting bolts
      3. remove motor pulley

3. Install new motor on the system in the correct manner displaying good workmanship.

   a. Make sure all electrical connections are tight.

   b. Make sure the fan motor is wired correctly.

   c. Make sure all mounting bolts are tight.

   d. Adjust belt, if belt driven.

   e. Make sure fan and motor turn freely before start up.

   f. Start motor.

   g. Observe performance.

4. Obtain instructor for evaluation.

Test, Remove, and Replace Condenser Fan Motor

1. It is always a good practice to make certain tests on a condensor fan motor before removal. The following tests should be made:

   a. Make sure ample voltage is supplied to the fan motor.

   b. All electrical connections should be checked.

   c. Test all components of the fan motor.
      1. relay or centrifugal switch
      2. start capacitor (CS motors)
      3. run capacitor (PSC motors)

   d. Test resistance on all motor windings.

   e. Test for shorted or grounded windings.

   f. Test motor shaft bearings (make sure shaft turns freely), test for loose bearings and excessive end and side play of shaft.

   g. Check for loose mounting bolts, or loose connections.

   h. Check for loose fan blade.

   i. Check for out of balanced fan blade.

   j. Check lubrication, if applicable.

2. If the condensor fan motor is defective, as the result of testing, use the following guideline for removal of motor.

   a. Turn the electrical power off.

   b. Remove the electrical wiring.

   c. Remove motor mounting bolts.

   d. Remove fan blade (with caution).

   e. Obtain all information from the motor name plate for ordering purposes.

3. Install new motor on the system as follows:

   a. Install fan blade.

   b. Install motor.

   c. Install the electrical connections.

   d. Turn fan blade with hand to assure free movement.

   e. Turn power on from switch.

   f. Observe operation and performance.

   g. Make sure the rotation of the motor is correct.

4. Obtain instructor for evaluation.

MAJOR BLOCK Air Conditioning **NAME** _____

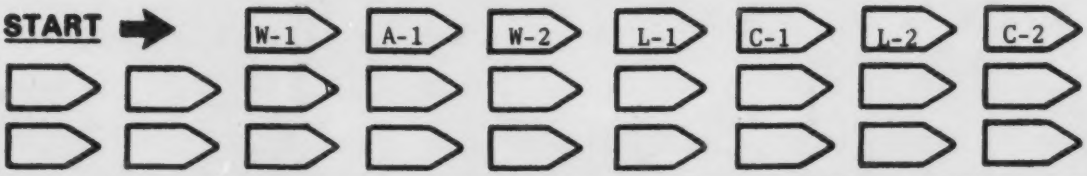
TASK Troubleshooting & Servicing

UNIT Performing pre-season start up **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-19

OBJECTIVE(S)

Perform pre season start up



WRITTEN ASSIGNMENT(S)

W-1	Information Sheet AC-19a
W-2	Text Assignment AC-19a
W-3	
W-4	
W-5	
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set AC-19a
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet AC-19a
L-2	Job Sheet AC-19b
L-3	
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

PROCEDURES FOR PERFORMING A PRE-SEASON START UP

The performance of any air conditioning equipment is based upon proper installation, good start up procedures, and expert servicing. The manufacturer realizes the importance of these services and will often enclose information to assist the technician in performing them. After new installation has been completed, necessary inspections and start up procedures should be carried out each season during the warranty period. When the warranty period has expired it is a good practice for the dealer to arrange for a service contract with the customer. In lieu of a service contract the customer has the option of calling the dealer for service or pre-season start up.

One aspect of some of the air conditioning units that are on the market today is the solid state system. These units must be checked out with the proper test equipment or by changing out the module with a known serviceable assembly. Another aspect to consider is the pilot light (depending on the type of heating and air conditioning system). Due to the push for energy conservation many heating and air conditioning service technicians recommend that the pilot be turned off during the warmer months. This decision however must be made by the customer after considering all alternatives.

There are probably twelve to fifteen steps to follow while performing a system pre-season start up. These steps may vary according to each manufacturer, but basically, they are all the same.

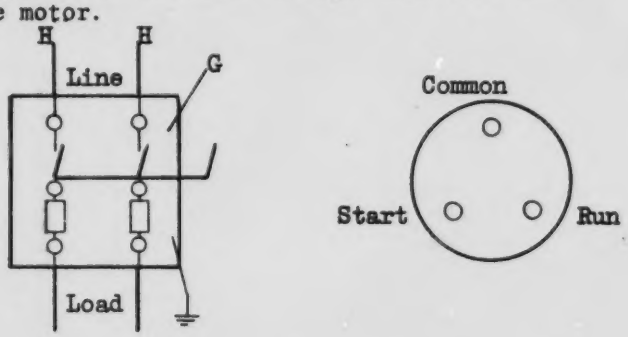
There are many steps and guidelines to follow while inspecting and starting up an air conditioning system. Listed are a number of steps that should be checked by the technician during a pre-season start up. First, a suggested list is given for the OUTSIDE UNIT. An illustration or a written statement, will follow each step describing the correct method of good testing and workmanship.

Observe an air conditioning system in the lab area and locate each item entered on the following check list. Obtain assistance from the instructor, if needed.

OUTSIDE UNIT

1. Voltage Check - Test voltage at the line side of the fuse disconnect or circuit breaker. Then turn the switch on and test the voltage at the load side. The voltage should read the same. To further check the voltage to the compressor place volt meter leads on common and run terminals. The voltage reading at these terminals should read near the incoming voltage. Compare the recorded voltage with that of the nameplate on the motor.

FIGURE A



2. Check F.L.A. During System Operation - The motor nameplate will give valuable information to the technician. The voltage and ampere readings should correspond with each other. While the motor is running, check and record the F.L.A. amps. Make sure the recorded amps is approximate with that of the nameplate.

FIGURE B

MOTOR NAMEPLATE

MOD._____SER._____
FRAME_____TYPE_____
VOLTAGE_____CYCLE_____
LRA_____FLA_____
RPM_____H.P._____

3. Check For Loose Electrical Connections - a suggested list of electrical connections are as follows:
    1. Terminals located on the line and load side of the fuse disconnect or circuit breaker.
    2. Motor terminals.
    3. Capacitor and relay terminals.
    4. Low voltage terminals.
    5. Contactor terminals.

4. Compressor Oil Level Check (if applicable) - The oil level in the compressor should be about 1/2 to 3/4 full on the oil sight glass provided the compressor has one. If not by cracking a flare nut on the liquid may detect some oil content on the fingers as liquid sprays out. (take caution while performing this test)

5. Check Freon Charge
    (A) While running, the pressures should be normal. Between 65 and 70 lbs. PSIG on the low side and 225 to 250 on the high side, using R-22 refrigerant.
    (B) If below normal pressures are obtained, the system should be checked for freon charge.

6. Check for Freon Leaks - Leaks may appear at any location in the air conditioning system. Check all solder joints and locations where the tubing may vibrate. If the system is full of freon, a visual check may be appropriate rather than using the leak test equipment.

7. Check Low and High Side Pressures - Install the gauge and manifold set to check the operating pressures on the system as stated in check no. 5, on R-22 systems. Pressures will vary according to load conditions.

8. Oil Condenser Fan Motors - If applicable, oil the fan motor with a good grade of oil. Some fan motors have oil cups (front and back) for lubrication. However, other fan motors have sealed bearings and cannot be oiled.

9. Check Air Flow Across the Condenser - The condenser may become clogged with dirt, lint, or leaves which will restrict the air flow. A condensing unit installed in confined air space may cause problems with high head pressure.

Likewise, the INSIDE UNIT has components that should be checked during the pre-season start up. An illustration, or a written statement, will accompany each step describing the methods of good testing and workmanship. Please observe an air conditioning system in the lab area and locate each component that is entered on the following checklist. Obtain assistance from the instructor, if needed.

INSIDE UNIT

1. Voltage Check - The voltage applied on the inside unit is 115 v single phase. Test the voltage at the circuit breaker to assure proper voltage for the motors, etc.

2. Check fan motor Amperes (while running) - The proper way to test F.L.A. on the motor is to read and record amps as shown on the amprobe during motor performance. This test should be made from the run or common source and not from start terminal.

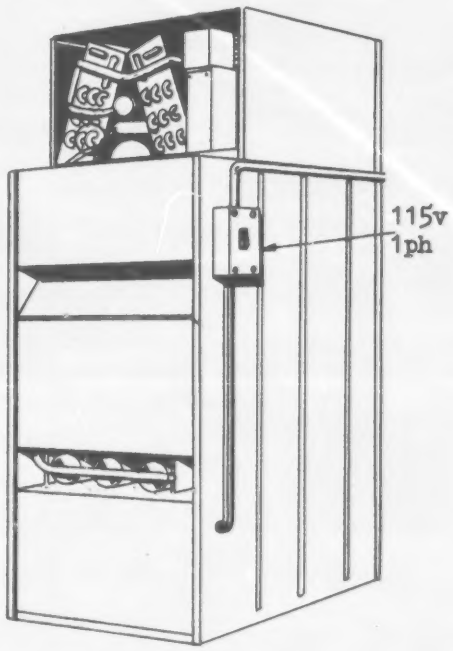
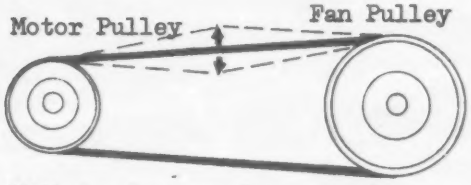


FIGURE C



With hand, pressing up and down, allow approximately 3/4" to 1" tension

FIGURE D

3. Check Belt Tension and Condition (if belt driven) - The inside unit may feature a direct drive fan or it may be a belt driven. The belt that drives the blower should be checked for alignment and belt tension. The belt tension should be approximately 3/4" to 1" tolerance while pressing the belt up and down. Ten to fifteen lbs. pressure will suffice.

4. Lubricate Fan Motor (if applicable) - Some of the fan motors can be lubricated with oil or grease. The sleeve bearings uses oil while the ball bearings use grease, however, the fan motor may not always feature a place for lubrication.

5. Check Air Filter - The air filter is located in the return air duct and ad indicated in figure _ dust particles can clog the filter, reducing the capacity of the air conditioning system. Many later model units will have an electronic air filter rather than the conventional type. Observe one system in the lab area and locate the filter and determine the type.

6. Check Fan Blades For Possible Dust and Lint - Air conditioning systems that operate at any length of time without a filter can accumulate dust particles in the concave of the fan blade. This decreases the air volume from the fan and thereby reduces the system efficiency.

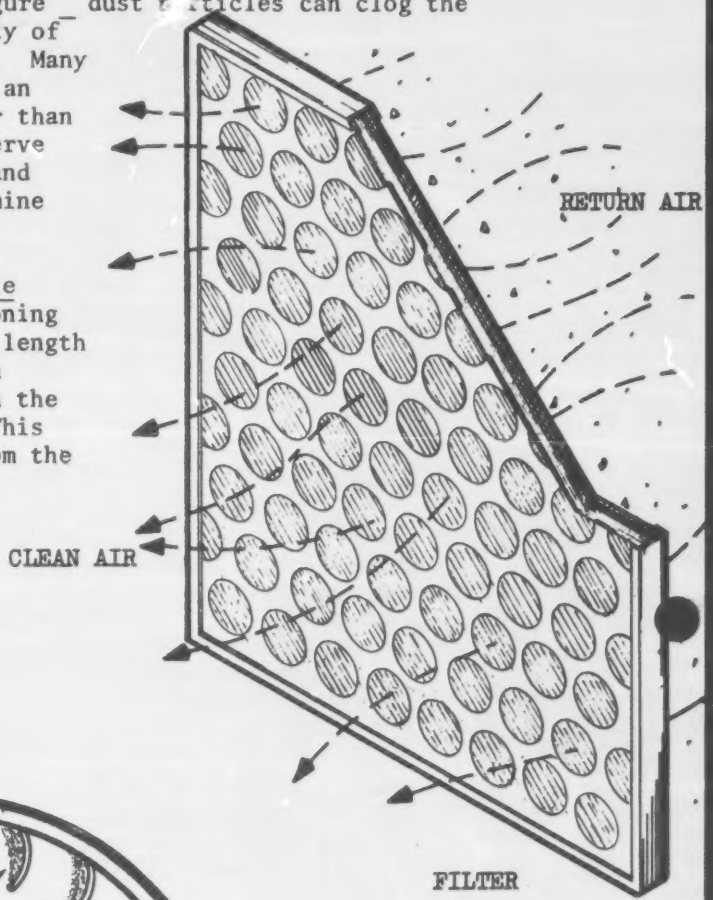


FIGURE E

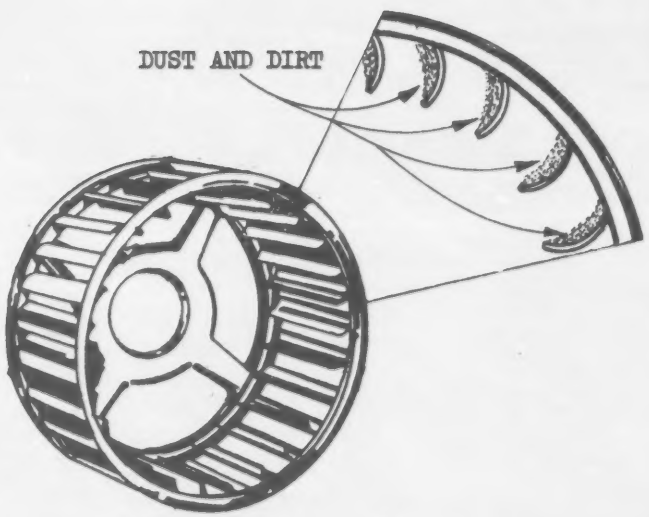


FIGURE F

7. Check for Loose Electrical Connections - Observe an inside unit and visually check the electrical wiring and determine the location of the connections. Possible places would be the disconnect or circuit breaker and the fan motor terminals.

8. Check Evaporator For Possible Blockage That Would Restrict Air Flow - There are two types of evaporators found on the inside unit. The upflow type is mounted on top of the unit and is usually called the "A" type. Observe one "upflow" type in the lab area. The down flow type is used when the air flow is going down rather than up. This type is mounted on the bottom of the inside unit. This is called the "slouted type" evaporator. Observe a "downflow" type evaporator in the lab area.

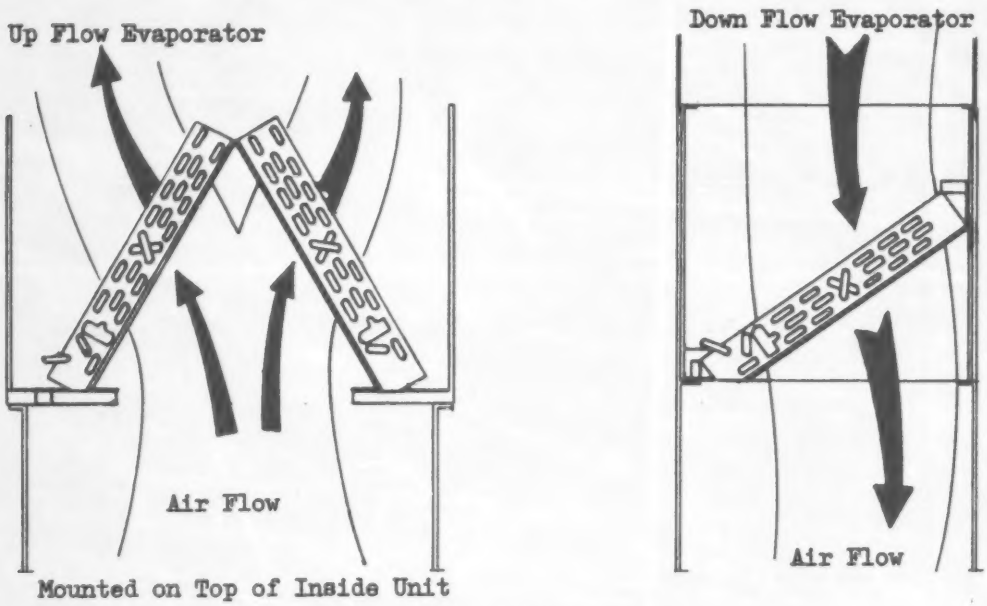


FIGURE 6

9. Check Temperature Drop Across The Evaporator - The temperature drop across the evaporator can be described as the temperature drop (T.D.) between the inlet air and the outlet air from the evaporator. The audio visual script will detail the procedure to determine the evaporator T.D.

10. Check Condensate Pump (if applicable) - The condensate pump is used in places where no drainage is available. Observe a pump in the lab area. Obtain instructor's assistance, if needed.

11. Place all panels, controls, covers, etc. on the Inside and Outside Units - Good working practices require that all systems be completely assembled upon completion of job performed.

1. Check with the instructor for assigned air conditioning system for pre-season start up.

2. Obtain necessary tools from the tool room:

   a. set of gauges
   b. amprobe
   c. VOM meter
   d. various wrenches, ratchet and screw driver

3. Install gauges on system.

   a. Note and record low and high side pressures.

      low side _____ high side _____

4. Test line voltage at top of fuse disconnect or circuit breaker.

   a. voltage recorded _____

5. Test condenser fan motor.

   a. Oil fan motor, if applicable.
   b. Make sure fan blade turns freely with the hand.

6. Check condenser for excessive blockage from dust, line, leaves, etc.

   a. Clean if necessary with air, freon vapor, or a good steel brush.

7. Test voltage at the fuse disconnect or circuit breaker on the inside unit.

   a. record voltage _____

8. Check fan motor and oil if applicable.

   a. Check fan belt, if belt driven; if defective, replace with the same type.

   b. Check fan blade for possible dust accumulation; clean if necessary.

9. Check evaporator coil if accessable, for excessive dust and lint accumulation on the fins. Clean if necessary.

10. Turn on pilot flame, if applicable.

11. Check air filter.

    a. Replace if dirty.

12. Check thermostat.

    a. Turn to cool position.
    b. Set temperature range.

13. Obtain instructor at this point for possible assistance or any questions that may be of importance.

14. Start the outside and inside units by turning the switches to "ON" position.

    a. Caution: the system may be equipped with a four minute time delay. If so, a waiting period of about four minutes will be in progress.

15. When the unit starts there are several tests that should be made as soon as possible.

    a. Test and record the compressor readings.

       amperes _____ nameplate amps _____

    b. Check gauge pressure and record readings.

       1. high side _____ 2. low side _____

    c. Check operation of the unit.

       1. Detect any noise that may occur on the blower assembly or blower motor.

16. Check the freon charge in the system.

    a. If low of freon test for leaks and repair if necessary.
    b. If freon charge is sufficient make the following test as listed on the next step.

17. Check the temperature drop (T.D.) across the evaporator.

    a. Make test and record results _____.

18. Observe complete system operation for any malfunction, loose electrical wires, abnormal noise, outlet air at all discharge room registers, etc.

19. Clean up work area, replace all cover panels, control covers and return all tools and gauges to the proper place.

MAJOR BLOCK Air Conditioning **NAME** _____

TASK Troubleshooting and Servicing

UNIT Troubleshooting Air Conditioner Refrigeration Cycle **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-20

OBJECTIVE(S)

Troubleshoot Air Conditioner Refrigeration Cycle

START → W-1 W-2 A-1 L-1 C-1 W-3 W-4

L-2 C-2 A-2 W-5 L-3 C-3

WRITTEN ASSIGNMENT(S)

W-1	Text Assignment AC-20a
W-2	Information Sheet AC-20a
W-3	Information Sheet AC-20b
W-4	Information Sheet AC-20c
W-5	Information Sheet AC-20d
W-6	
W-7	

AUDIOVISUAL(S)

A-1	Slide Set AC-20a
A-2	Slide Set AC-20b
A-3	
A-4	
A-5	
A-6	
A-7	

LABORATORY ASSIGNMENT(S)

L-1	Job Sheet AC-20a
L-2	Job Sheet AC-20b
L-3	Job Sheet AC-20c
L-4	
L-5	
L-6	
L-7	
L-8	
L-9	

CHECKPOINT(S)

C-1	Instructor Check
C-2	Instructor Check
C-3	Instructor Check
C-4	
C-5	
C-6	
C-7	
C-8	
C-9	

Determine Proper Charge

It is important to use manifold gauges, thermometers and other instruments when servicing and diagnosing problems in air conditioning systems. Service technicians cannot properly diagnose a malfunction within a system without the use of these testing devices.

Each of these testing devices has its own purpose. For example, the manifold gauges measure the low and high side system pressures; VOM's measure the electrical data and the thermometer measures the temperature at any given part of the refrigeration cycle. All of these measuring devices are considered a necessity in testing and diagnosing a problem area in an operational air conditioning system.

The manifold gauges must be used by the technician to charge the system with freon. The low side gauge line should be attached to the low side of the compressor while the high side gauge is attached to the high side of the system. The center gauge line is attached to the freon drum. (See Figure A). The technician should constantly check and read the low and high pressures while charging freon into a system.

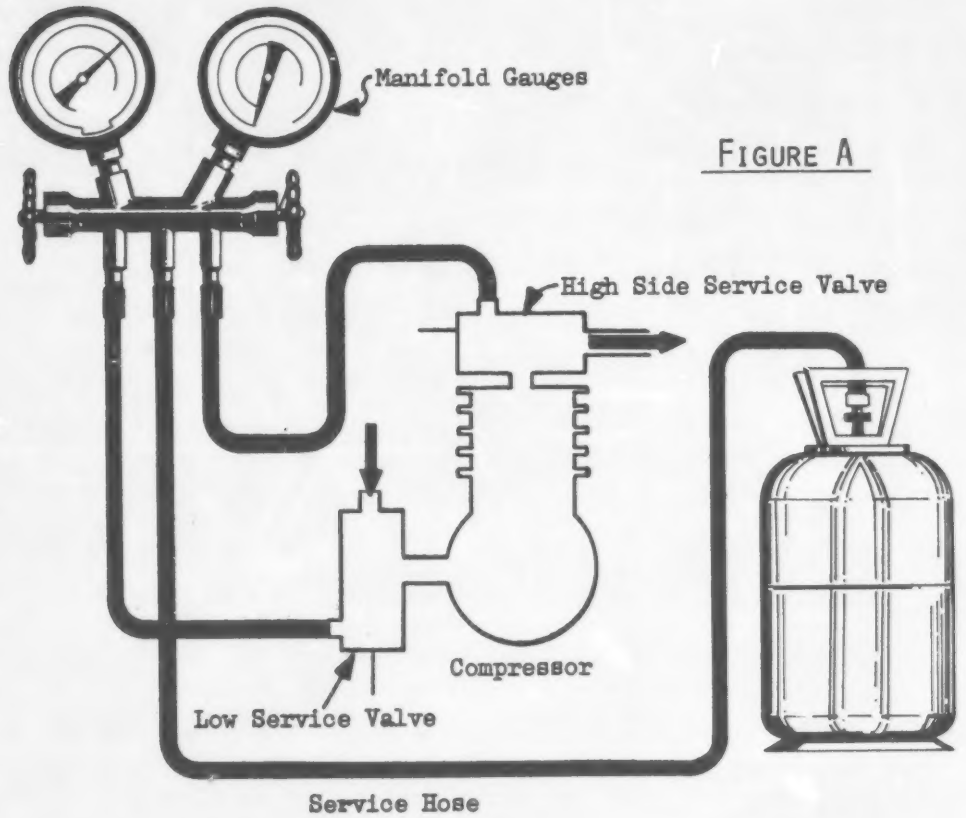


FIGURE A

The thermometer should be used when charging a system with freon. First, the ambient temperature should be a known factor in charging the system. Ambient temperature plus 30 to 32 degrees F. converted into pressure should determine the discharge or high side pressure while the system is running.

The discharge pressure should generally not exceed the pressure of that which corresponds to the ambient temperature (air cooled units) plus 30 to 32 degrees F. This will apply to R-22 systems when the suction pressure is at approximately 70 PSIG. It may be noted that this is one of the many ways to charge the system. It is best to follow the manufacturer's recommendations relating to specifications of charging specific air conditioning systems.

Another method to charge refrigerant into a system is the weigh in process. To assure the correct weight the system should be free of all freon before weighing the correct amount of charge in.

The superheat method of charging a system is very popular in determining the charge of a system. It is a process which obtains the ambient temperature reading and records the suction pressure by converting the pressure to temperature and measuring the suction line temperature. The audio visual script will detail the process thoroughly.

The evaporator temperature difference (T.D.) method may also be considered as a good method to determine a proper refrigerant charge in a system. The inlet and outlet air temperature through the evaporator will normally be about 15° to 18° F. difference. Example:

Inlet air	80 degrees F
Outlet air	65 degrees F
Temp. difference	15 degrees F

The inlet and outlet air can vary at a higher or lower temperature.

To correctly charge a system, the technician should possess a thorough knowledge of the basic theory and fundamentals of the refrigeration and air conditioning cycle. By combining this knowledge with a good charging procedure, the technician can properly determine a correct charge in any given system.

Determine Proper Charge

The instructor will assign an air conditioning system from the lab area for the purpose of "Determining Proper Charge" by the Weigh In Method.

1. Remove refrigerant from the system. (gauges must be installed).
2. Obtain charging cylinder from the tool or storage room.
3. Weigh or measure into charging cylinder as per name plate or manufacturer's specifications.
4. Charge the measured quantity into the system.
5. Run system for a short time to determine the correct charge.
6. Ask the instructor to verify workmanship, accuracy and evaluation of assigned job.

The instructor will assign an air conditioning system from the lab area for the purpose of "Determining Proper Charge" by the Ambient Temperature Method.

1. Read and record the ambient temperature near the condensing unit.
2. Add 30 to 32 degrees F. to the ambient temperature and arrive at total.
3. Locate the total temperature on the temperature column from the temperature pressure chart.
4. Record the corresponding pressure under the correct freon column.
5. Read the high side pressure while the system is in operation. (gauges must be installed).
6. Adjust freon in the system until the high side pressure is in accordance with the corresponding pressure of the total temperature figure.

Example:	ambient temperature	90F
	add to 90F	30F
	Total	120F

Corresponding pressure (R-22) 259.9 PSIG

The instructor will assign one air conditioning system from the lab area for the purpose of "Determining a Proper Charge" by the Superheat Method.

1. Record ambient temperature.
2. Record suction pressure (gauges must be installed).
3. Convert suction pressure to temperature (R-22).
4. Select superheat from the ambient temperature chart.
5. Total numbers 3 and 4 above.
6. The total should be the suction line temperature when fully charged. (Record the temperature on the suction line near the compressor.
7. Run the system for a while to insure proper charge.
8. Ask the instructor to verify workmanship, accuracy and evaluation of the assigned job.

Reference: SUPERHEAT CHART

Ambient temperature D.B.	Superheat
100 - 110 F	10 F
90 - 99 F	15 F
70 - 89 F	20 F

Handling Low Charge

The air conditioning system is a combination of components and accessories assembled together with copper tubing. The connections are usually made utilizing flares and sweat joints. Due to the high and low temperatures and pressures encountered during the system performance, freon leaks will occur which will cause a shortage of refrigerant in the system. Vibration will also cause tubing breakage. Should a system develop a shortage of freon due to a copper line breakage, it is best to locate the leak using a leak detector. There are three very common ways the technician can perform a leak test on a system. The soap bubbles method, (A); the halide torch method, (B); and the electronic detector, (C). Most competent technicians choose the best leak detector for the conditions encountered.

There are several characteristics of a low charge which can be determined during system operation. Some of these methods are:

1. low suction pressure
2. icing evaporator coil
3. evaporator temperature drop too great
4. warm suction line
5. high side pressure low
6. running cycle too long
7. room temperature too high

It should be noted that some of the above symptoms may occur with problems other than a low freon charge. The technician must determine the problem area.

Handling an Overcharge or a Non-condensable

An overcharge of refrigerant in the operating system can cause serious damage to the compressor. On the capillary tube system, an overflow of liquid refrigerant down the suction line can dilute the oil in the compressor base. This will reduce the lubrication value of the oil, and cause bearing failure.

An overcharge of refrigerant on the capillary tube system may damage the suction and discharge reed valves in the compressor. The service technician will note higher than normal low and high side gauge pressure readings due to an overcharge of refrigerant in the system. Should a system become overcharged by some unknown reason the freon should be purged from the system until the correct charge is obtained.

Non condensable air in the air conditioning system can cause major problems during system operation. Some of the problems are,

1. high head pressure
2. moisture in the system
3. freeze up of the metering device
4. acids in the system
5. reduced life of the equipment

There are several methods of removing air from a system:

1. While the system is off, purge the air from the high side.
2. Remove the refrigerant, purge and recharge.
3. Remove the refrigerant and evacuate with vacuum pump.

With the appearance of air and moisture in the system it is best to install a good filter-drier in the liquid line. The filter-drier should be installed into the liquid line at a position prior to the flow into the metering device.

Troubleshooting the refrigeration cycle - Low Charge

A. The instructor will assign to the student an air conditioning system which has a shortage of refrigerant.

Outline for student work procedures:

1. Install manifold gauges.
2. Turn system "ON".
3. Run the system for _____ (time to be specified by the instructor).
4. Record low side pressure _____PSIG.
5. Record high side pressure _____PSIG.
6. Record ambient temperature at condensing unit. _____F.
7. Record temperature on suction line near the compressor _____F.
8. Select proper superheat as per ambient temperature. (See reference table at the end of this job sheet).
9. Record temperature drop across the evaporator coil. _____F.
10. From information above determine if the system needs freon added.

    10a. NO, ask the instructor to evaluate the activity.
    10b. YES, proceed to charge the system until all pressures and temperatures are correct.

B. Record new readings on outline provided below. This should be done on the same equipment used in "A" above after the system has been charged. (System must be in operation).

1. Install manifold gauges.
2. Turn the system "ON."
3. Run the system for _____(time to be specified by the instructor).
4. Record low side pressure. _____PSIG.
5. Record high side pressure. _____PSIG.
6. Record ambient temperature _____F.
7. Record temperature on suction line near the compressor _____F.
8. Record superheat as per outside ambient temperature (see Reference Table ____F).
9. Record temperature drop across the evaporator coil, charge the system, and ask the instructor to evaluate the activity.

REFERENCE TABLE:

Ambient temperature D.B.	Superheat
100 - 110 F	10 F
90 - 99 F	15 F
70 - 89 F	20 F

Troubleshooting the refrigeration cycle - High Charge

C. The instructor will assign an air conditioning system which has an overcharge of refrigerant.

Outline for student work procedures:

1. Install manifold gauges.
2. Turn system "ON".
3. Run the system for _____(time to be specified by the instructor) CAUTION: An overcharge of freon in a system will cause excessive liquid refrigerant in the compressor. If so, purge as needed. (only apply to capillary tube systems).
4. Record low side pressure _____PSIG.
5. Record high side pressure _____PSIG.
6. Record ambient temperature at condensing unit.
7. Record temperature on suction line near the compressor _____F.
8. Select proper superheat as per ambient temperature (see reference table).
9. Record temperature drop across the evaporator coil _____F.
10. Use the above information to determine if the system overcharged?
11. Ask the instructor to evaluate this activity.

D. The instructor will assign an air conditioning system which contains non-condensables.

1. Install manifold gauges.
2. Turn the system "ON".
3. Run the system for _____(time to be specified by the instructor).
4. Record the low side pressure _____F.
5. Record the high side pressure _____F.
6. Run the system for a period of 5 to 10 minutes.
7. Stop system and remove wiring to compressor.
8. Run the condenser fan for a time until ambient and condenser temperature are equal.
9. Record high side pressure _____F.
10. Compare recorded pressure on the temperature pressure chart according to type of freon in the system and ambient temperature conditions.
11. If system high side pressure is greater than the temperature pressure chart, non-condensable air is in the system.
12. If the pressures are correct, air is not in the system.
13. Should non-condensables occur in the system, purge until the pressures are satisfied.
14. Ask the instructor to evaluate this activity.

Troubleshooting by symptoms

SYMPTOMS	SOLUTION
1. Running cycle too long a. insufficient freon charge	Test for leaks and charge with freon until correctly charged
2. Excessive head pressure a. overcharged with freon b. air in system	Purge freon until correct charge is maintained
3. Temperature too high in conditioned space a. short of freon b. dirty filter c. dirty evaporator d. defective compressor	a. add freon to system until correct charge is maintained b. replace air filter c. clean evaporator to permit sufficient air flow d. repair or replace compressor
4. Low head pressure a. low refrigerant charge b. dirty air filter c. dirty evaporator d. ambient temperature too low e. restricted metering device	a. charge system with freon until correct b. replace filter c. clean evaporator to permit good air flow d. install condenser fan cycling control e. clean or replace metering device
5. Noncondensables in system a. excessive air	Purge air from system until all pressures and temperatures are in accordance with normal system operation
6. Excessvie frost on evaporator coil	Inspect air filter, inspect fan blade, check for low charge, check for restriction, check fan motor.

The instructor will assign a unit that has one or more of the problems discussed in this Task. Locate the problem and fill in the information requested below.

Unit Serial Number _____

Problem area(s) _____

How did you find the problem?

_____

_____

_____

_____

How can the problem be solved?

_____

_____

_____

_____

MAJOR BLOCK Air Conditioning **NAME** _____

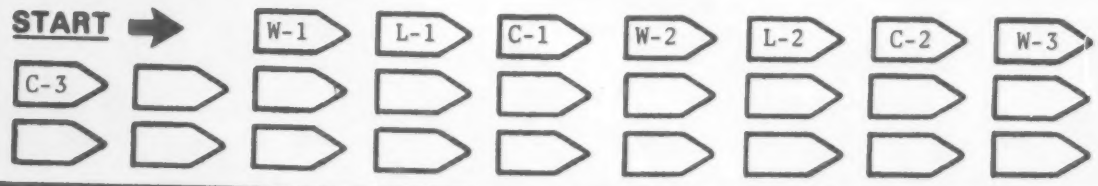
TASK Troubleshooting and Servicing

UNIT Troubleshooting air conditioners (electrical cycle) **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-21

OBJECTIVE(S)

Troubleshooting electrical cycle of air conditioning system



WRITTEN ASSIGNMENT(S)

W-1 Information Sheet AC-21a
W-2 Information Sheet AC-21b
W-3 Information Sheet AC-21c
W-4 _____
W-5 _____
W-6 _____
W-7 _____

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet AC-21a
L-2 Job Sheet AC-21b
L-3 _____
L-4 _____
L-5 _____
L-6 _____
L-7 _____
L-8 _____
L-9 _____

AUDIOVISUAL(S)

A-1 _____
A-2 _____
A-3 _____
A-4 _____
A-5 _____
A-6 _____
A-7 _____

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 _____
C-5 _____
C-6 _____
C-7 _____
C-8 _____
C-9 _____

Check Unit for Proper Incoming Voltage

Voltage is important for air conditioning systems that depend upon electricity for performance. Voltage, as we know it today, is generated at the power plant and distributed through high voltage wires. Transformers are used at certain places along the high voltage circuit to reduce the incoming voltage to meet the requirements of the main entrance panel in a building or a home. Without sufficient voltage at the service entrance and circuit breakers, the equipment will not perform efficiently.

The service technician should read and record all name plate data from the equipment to be serviced or repaired. For example, if the name plate data reads 230 volts, single phase, the service technician should first determine if incoming voltage is appropriate. When checking voltage use caution, 230 volts can seriously injure or cause the death of a careless technician.

Power companys supply residential areas with 230 volts, single phase. Usually a 3-wire service will extend from the transformer on the pole to the service entrance. Two of the wires are 115 volts each and the third wire is the neutral, or ground. The color code will identify each of the three wires. White is neutral or ground while black and red are each 115 volts.

An illustration will show this circuit from the transformer on the pole to the main entrance panel, (color codes may vary in different areas).

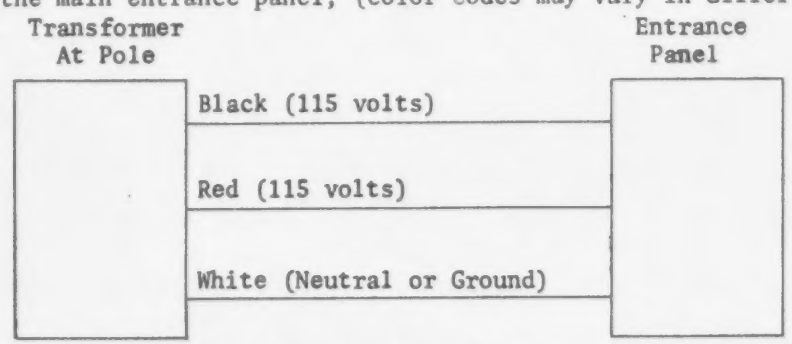


FIGURE A

If the technician has the knowledge and ability to recognize the incoming electrical circuit, there should be no problem in testing the voltage at the distribution panel and at the concensing unit breaker or seitch.

Usually, the air conditioning condensing unit will feature 230 volts, single phase, while the inside unit will be 115 volts, single phase. The control circuit will generally be 24 volts which is reduced down by the use of a transformer. Each of these circuits should be tested separately when diagnosing a problem area.

It is not unusual to encounter electrical problems when servicing air conditioners. Without substantial electrical knowledge, the service technician may encounter unsolvable problems while installing and servicing these systems.

Check Unit for Proper Incoming Voltage

A. The instructor will assign an air conditioning system to the student for the purpose of checking and testing voltage to the outside and inside units.

1. Locate and record the name plate voltage data on the following components:

   a. motor compressor _____ volts

   b. condenser for motor _____ volts

   c. cabinet (outside unit) _____ volts

   d. cabinet (inside unit) _____ volts

   e. fan motor (inside unit) _____ volts

2. Test voltage at the following places: (use caution)

   a. service entrance/distribution panel _____ volts

   b. circuit breaker or fuseable disconnect (outside unit) _____ volts

   c. circuit breaker or fuseable disconnect (inside unit) _____ volts

   d. fan motor (inside unit) _____ volts

B. As a rule of thumb, all the voltage entries should be within five to ten percent of the equipment name plate data. If the recorded voltage does not measure within this range, the student will attempt to locate the problem area.

C. Ask the instructor to evaluate this activity

Check all Control Components

Major manufacturers usually enclose an installation instruction manual with their equipment upon shipment to the various distributors. The purpose of these manuals is to give technical information to the installer or service technician engaged in servicing or repairing their equipment. These manuals relate all the electrical data and other information to the technician. It is a good practice to follow the manufacturer's schematics or pictorial wiring diagrams while testing the electrical problems in the system. There are several basic electrical components in the air conditioning system that the technician must test in order to locate an electrical fault in the system. Each of the major components will be illustrated by a drawing and the procedure for testing.

To check a circuit breaker, it is best to make a voltage test across the line terminals, then across the load terminals, while the switch is "ON." If full voltage is measured, the breaker is good.

Circuit Breaker

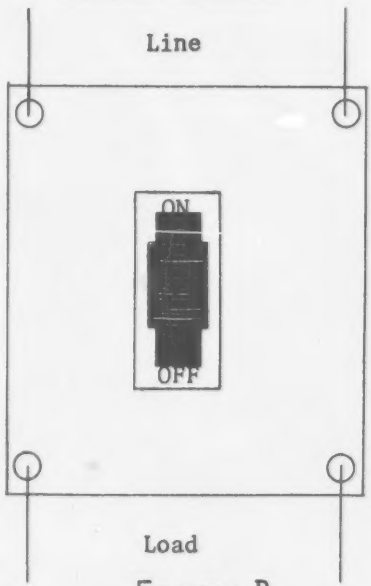


FIGURE B

The continuity test is another method of testing a circuit breaker while the switch is "ON". Remove the electrical wiring from all the terminals and place the ohmmeter probes between each line and load terminals. Approximately zero ohms would indicate a good breaker. CAUTION: Power must be off to make this test or ohmmeter burnout will result. Also, check for discoloring on the terminals and the over all appearance. The contactor is another major component that should not be overlooked while testing electrical problems.

Contactor

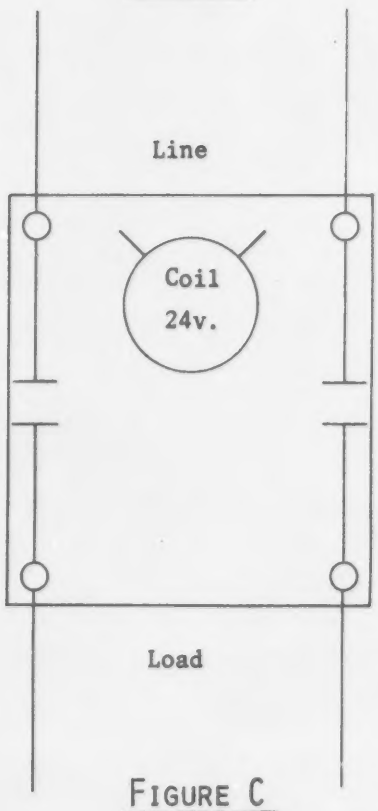


FIGURE C

There are several faults which may be detected while testing the contactor. The holding coil (24v) may become defective resulting in: 1. A broken pathway which would be indicated by the absence of continuity in the contactor. 2. A zero ohm reading would indicate a short circuit. 3. The contacts may become burned due to excessive arcing. 4. The terminals located on the line and load sides may become discolored or burned due to loose connections.

If the contactor is good, full voltage should be measured across the load terminals while the coil is energized. While the power is off, a continuity test may be made provided the contacts are closed. Relays are commonly used in the air conditioning systems and usually consist of a low voltage relay coil and a set of normally closed and open contacts. This relay is used to run the inside fan during the "Cooling Cycle", and is better known as the fan relay.

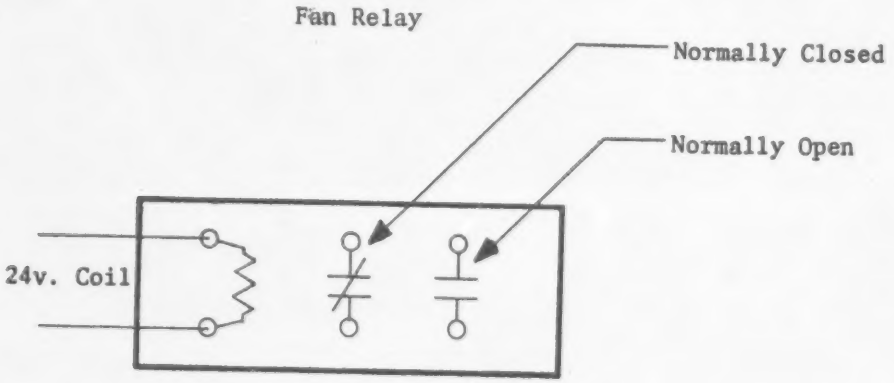


FIGURE D

To test the 24v coil, place the ohmmeter leads across the coil terminals. A resistance reading on the meter would represent a good coil. No reading would indicate a broken pathway and a defective coil. A continuity reading on the normally closed contacts would be good. The normally open contacts should not have a reading unless the coil of the relay is energized.

The transformer is used on the cooling system to reduce the 115 volts down to 24 volts. Most of the control devices are specified for low voltage.

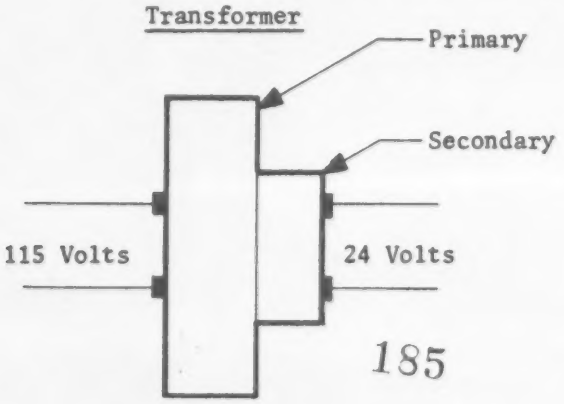
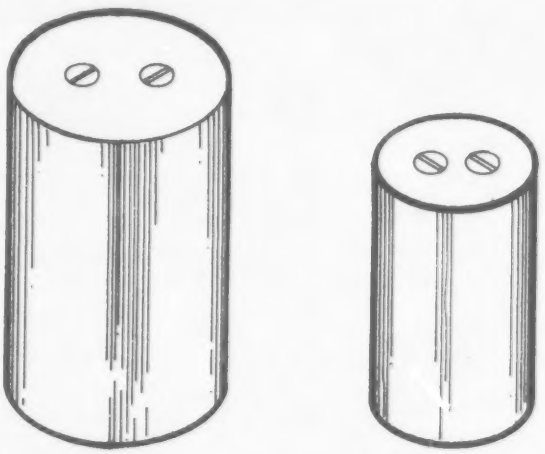


FIGURE E

A voltage test can be used to check the transformer. With 115 volts applied to the primary, 24 volts should be measured on the secondary, which would reflect a good transformer. A continuity test can be applied on the primary and secondary. A resistance reading would indicate a good transformer, no reading would reflect a bad transformer.

Capacitors are used in the air conditioning systems to increase the efficiency of the motors or to give the motors a high starting torque. Two best known capacitors are the START and RUN capacitors



Capacitors

FIGURE F

The start and run capacitors can be tested with a capacitor tester or by the ohm test with the VOM meter. First, bleed the capacitor off with the volt meter, then place ohmmeter probes to the terminals. The meter should read ohms and then slowly drop down to zero. This would indicate a good capacitor. If the pointer of the ohmmeter does not drop back to zero the capacitor is shorted and needs to be replaced.

The thermostat is a device that controls the cycling of the condensing unit in order to maintain a given temperature based on the setting.

Thermostat

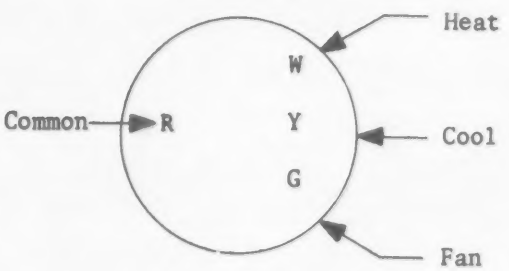


FIGURE G

The thermostat is usually 24 volts rather than line voltage. The ohmmeter can be used to test the circuits of the thermostat. If continuity exists between R and W terminals the heat circuit is good provided the setting is on heat. If continuity exists between R and Y terminals the cooling circuit is good provided the setting is on cool.

Most of the major components have been identified and explained thus far, which should give the student sufficient knowledge on how to locate and diagnose a problem area. The wiring diagram in Figure H may be helpful in locating the various components within the electrical system.

NOTE: The low voltage high limit may be located on the white wire between the thermostat and the gas valve, instead of the common red wire.

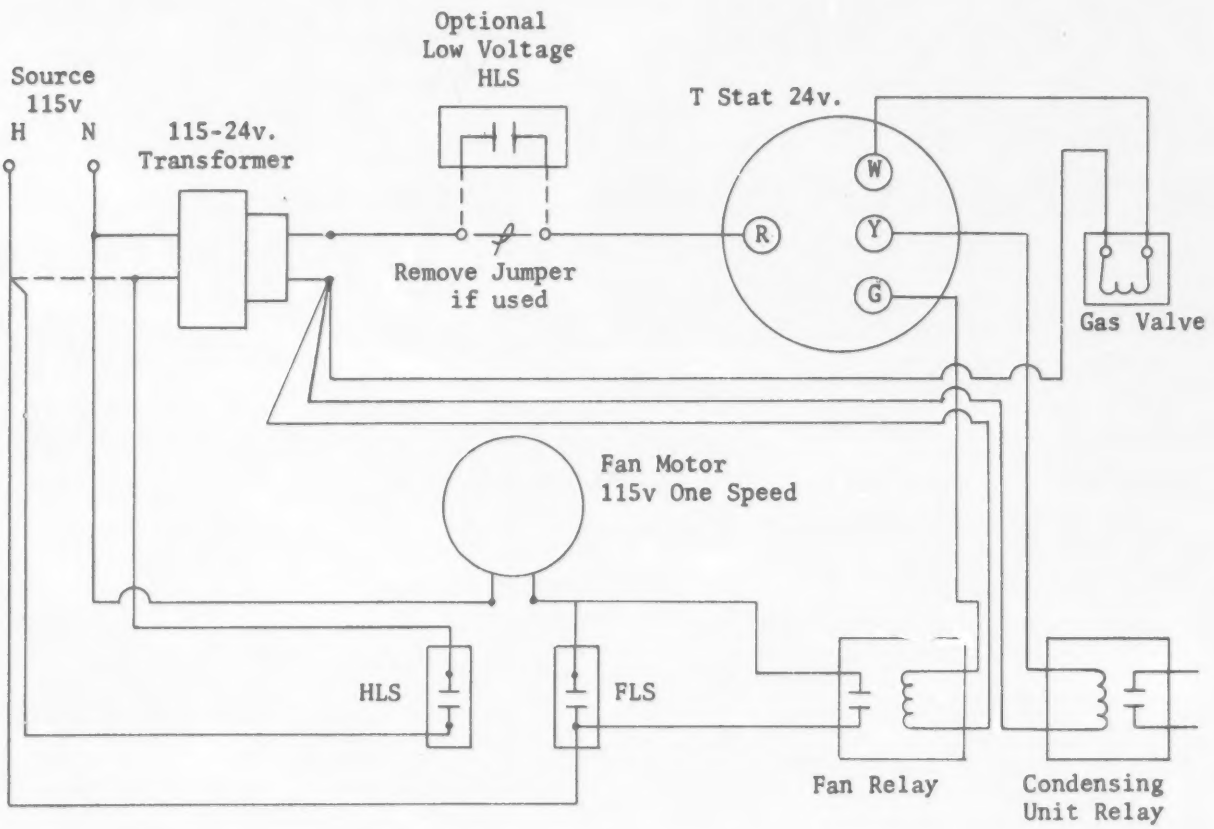


FIGURE H

Control Components

A. The following components will be located and tested on a live system as assigned by the instructor.

1. Circuit Breaker - Voltage and Continuity Test

a. With switch "ON" check voltage on line and load side of circuit breaker.

1. line side voltage _____.
2. load side voltage _____.

b. With all power "OFF" and electrical wires removed from the circuit breaker, make a continuity test with switch "ON".

1. ohms reading _____.

2. Contactor - Voltage and Continuity Test

a. With power "ON" test voltage from line to load terminals

1. voltage at line terminals _____.
2. voltage at load terminals _____.

b. With all power "OFF" and electrical wires removed from the contactor, make a continuity test.

1. continuity test _____.

3. Fan Relay - Voltage and Continuity Test

a. With power "ON" make a voltage test across the coil terminals.

1. voltage test _____.

b. With all power "OFF" and electrical wires removed from the relay, make a continuity test.

1. coil continuity test _____.
2. normal closed contacts _____.
3. normally open contacts _____.

4. Transformer - Voltage and Continuity Test

a. With power "ON" make a voltage test on the secondary side of the transformer.

1. voltage test _____.

b. With all power "OFF" and electrical wires removed, make a continuity test.

1. primary side _____.
2. secondary side _____.

5. Capacitors - capacitor tester and ohm test

   a. Run capacitor tests

      1. Test and record F.L.A. while compressor is running _____.
      2. Remove wire from one side of capacitor and record amps _____.
      3. If amps increase on the no. 2 test the capacitor is good. No increase in amps identifies a bad capacitor.
      4. Run capacitor - continuity test

         a. With all power "OFF" remove electrical wires from the capacitor.
         b. Make ohms test.
            1. good _____.
            2. bad _____.

      5. Run capacitor - capacitor tester

         a. Test the run capacitor with the capacitor tester.
            1. good _____.
            2. bad _____.
         b. Start capacitor - if applicable
            1. Start capacitor - continuity test
               a. With all power "OFF", remove electrical wires from the capacitor
               b. Make ohms test
                  1. good _____
                  2. bad _____
            2. Start capacitor - capictor tester
               a. Test the start capacitor
                  1. good _____
                  2. bad _____

6. Thermostat - Continuity Test

   a. With all power "OFF" and electrical wires removed make the following continuity tests:

      1. common to heat _____.
      2. common to cool _____.
      3. common to fan _____.
      4. check for level _____.

Troubleshooting by Symptoms

1) No power at circuit breaker 2) Contact will not energize	1) Test for power source at main disconnect or circuit breaker. 2) Test voltage on holding coil 3) Test transformer 4) Check for broken wire 5) Check for binding condition
3) No voltage on load side of contactor	1) Test voltage on line side of contactor 2) Test voltage on load side of contactor 3) Inspect contacts 4) Inspect electrical terminals
4) Fan relay will not energize	1) Test voltage across coil terminals 2) Test voltage from secondary of transformer 3) Test for broken wire
5) Fan motor will not run while on cooling cycle	1) Test voltage on relay coil terminals 2) Check for broken wire on fan relay circuit 3) Test transformer secondary for proper voltage 4) Check contacts on relay
6) Transformer voltage inefficient	1) Test line voltage to primary of transformer 2) Test voltage on secondary of transformer 3) Make continuity test of primary and secondary of transformer 4) Check (VA) rating on transformer 5) Compare primary voltage of transformer with line voltage
7) Run capacitor defective	1) Test MFC on capacitor 2) Test voltage 3) Check for leakage on capacitor 4) Check terminals on capacitor
8) Start capacitor defective	1) Test MFC on capacitor 2) Test voltage 3) Check for leakage on capacitor 4) Check terminals on capacitor
9) Thermostat defective	1) Test circuits on thermostat 2) Check mercury bulb for being damaged 3) Check sub-base of thermostat 4) Check location of thermostat 5) Check if thermostat is level

MAJOR BLOCK Air Conditioning **NAME** _____

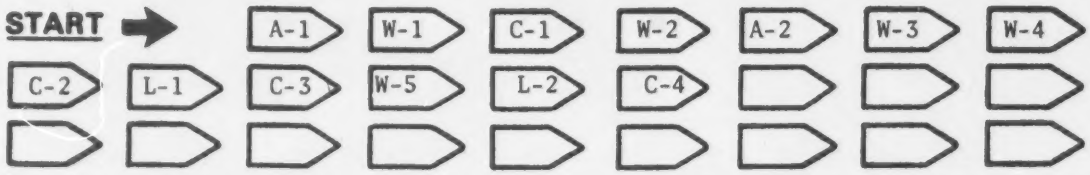
TASK Troubleshooting and Servicing

UNIT Troubleshooting air conditioners (air movement) **TIME (est.)** _____ **(act.)** _____

UNIT NO AC-22

OBJECTIVE(S)

Troubleshoot and service the condenser and evaporator coils (air movement).



WRITTEN ASSIGNMENT(S)

W-1 Assignment Sheet AC-22a
W-2 Text Assignment AC-22a
W-3 Information Sheet AC-22a
W-4 Assignment Sheet AC-22b
W-5 Assignment Sheet AC-22c
W-6
W-7

AUDIOVISUAL(S)

A-1 Slide Set AC-22a
A-2 Slide Set AC-22b
A-3
A-4
A-5
A-6
A-7

LABORATORY ASSIGNMENT(S)

L-1 Job Sheet AC-22a
L-2 Job Sheet AC-22b
L-3
L-4
L-5
L-6
L-7
L-8
L-9

CHECKPOINT(S)

C-1 Instructor Check
C-2 Instructor Check
C-3 Instructor Check
C-4 Instructor Check
C-5
C-6
C-7
C-8
C-9

Troubleshooting Air Conditioners (Air Movement)

To identify different types of coils

A. The student will locate and observe several air-cooled condensers of different designs in the lab area.

	A/C unit serial #	Nomenclature
1. Note type of fan blade.	_____	_____
2. Determine rotation of fan blade assembly.	_____	_____
3. Note direction of air flow through several water cooled condenser.	_____	_____

B. The student will locate and observe several water cooled condensers of different designs in the lab area.

1. Note type of condenser.	_____	_____
2. Note inlet and outlet water connections.	_____	_____
3. Note inlet and outlet refrigerant connections.	_____	_____
4. Note water temperature difference between the water inlet and the water outlet. (Provided the system is in operation).	_____	_____

C. The student will locate and observe several evaporator coils of different designs in the lab area.

1. Obserbe an "A" evaporator coil (upflow).	_____	_____
2. Observe an "H" evaporator coil (horizontal).	_____	_____
3. Observe a "sloped" evaporator coil (down flow).	_____	_____
4. Observe a "cold water" evaporator coil, (if applicable).	_____	_____

TROUBLESHOOTING PROBLEM CHART

PROBLEM

1. Air passage through the condenser block approximately 1/4 to 1/3 (air cooled).

SYMPTOMS

1. head pressure extremely high
2. suction pressure too high
3. room temperature too high
4. compressor may trip on overload
5. liquid line too hot
6. long running cycle

PROBLEM

2. Freon leak in condenser (air cooled)

SYMPTOMS

1. system low on freon
2. low suction pressure
3. lower than normal head pressure
4. room temperature too high
5. icing on evaporator coil (A/C)
6. compressor temperature above normal
7. overload may be tripped out
8. cold liquid line
9. suction warmer than normal
10. evaporator superheat too high

PROBLEM

3. Ambient temperature too high (above 95 degrees) (air cooled)

SYMPTOMS

1. high head pressure
2. high suction pressure
3. liquid line too hot
4. evaporator temperature too high
5. long running cycle
6. room temperature too high
7. compressor overload may trip out

PROBLEM

4. Improper location which will restrict proper fresh air through the condenser, and or, sun rays will be too hot. (air cooled)

SYMPTOMS

1. high head pressure
2. high suction pressure
3. long running cycle
4. compressor overload may trip out
5. liquid line too hot
6. conditional area temperature above normal

PROBLEM

5. Scale accumulation inside of water coil (water cooled) condenser.

SYMPTOMS

1. high head pressure
2. outlet water to temperature too high
3. high suction pressure
4. compressor temperature too hot
5. overload trippled out
6. air temperature from evaporator too warm
7. conditional area temperature above normal
8. liquid line too warm

PROBLEM

6. Bursted water coil in condenser (water cooled).

SYMPTOMS

1. water in system
2. freeze up (in metering device)
3. oil diluted with water

PROBLEM

7. Water restriction, or inlet water too hot in condenser (water cooled).

SYMPTOMS

1. high head pressure
2. high suction pressure
3. liquid line two warm
4. trippled overload on compressor
5. conditioning area too warm
6. long running cycle

PROBLEM

8. Freon leak in evaporator (portable charge)

SYMPTOMS

1. low of freon
2. low suction pressure
3. below normal head pressure
4. warm suction line
5. compressor too warm
6. overload may trip out
7. icing on evaporator
8. evaporator superheat too high
9. liquid line temperature below normal

PROBLEM

9. Evaporator fins clogged with dust, lint or ice

SYMPTOMS

1. low suction pressure
2. possible frost back on suction line
3. lower than normal head pressure
4. air volume low or restricted
5. conditioned area too warm
6. long running cycle
7. icing on evaporator
8. cold suction line

Common Symptoms In Coils

Use the "Troubleshooting Problem Chart" to match problems with symptoms. Some symptoms will be identified with more than one problem. If this is the case they will be duplicated in the systems list. Use each letter only one time.

PROBLEMS

Condensers

A. Air passage through the condenser blocked approximately 1/4 to 1/3 (air cooled).

1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

B. Freon leak in condenser (air cooled)

1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

C. Ambient temperature too high (above 95 degrees) (air cooled)

1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

D. Improper location which will restrict proper fresh air through the condenser, and or, sun rays will be too hot. (air cooled)

1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

SYMPTOMS

a. conditional area temp above normal
b. head pressure extremely high
c. liquid line too hot
d. suction pressure above normal
e. compressor overload may trip out
f. room temperature too high
g. long running cycle
h. compressor may trip on overload
i. high suction pressure
j. liquid line too hot
k. high head pressure
l. long running cycle
m. compressor overload may trip out
n. system low on freon
o. room temperature too high
p. low suction pressure
q. long running cycle
r. lower than normal head pressure
s. evaporator temperature too high
t. room temperature too high
u. liquid line too hot
v. icing on evaporator coil (A/C)
w. high suction pressure
x. compressor temperature above normal
y. high head pressure
z. overload may be tripped out
aa. cold suction line
bb. high head pressure
cc. icing on evaporator
dd. outlet water to temp too high
ee. low suction pressure
ff. water in system
gg. liquid line temperature below normal
hh. high suction pressure
ii. icing on evaporator
jj. low of freon
kk. air temperature from evaporator too wa
ll. long running cycle
mm. conditional area temperature above nor
nn. overload may trip out
oo. oil diluted with water
pp. trippled overload on compressor
qq. liquid line too warm
rr. compressor temperature too hot

PROBLEMS

E. Scale accumulation inside of water coil (water cooled) condenser

1. _____ 5. _____
2. _____ 6. _____
3. _____ 7. _____
4. _____ 8. _____

F. Bursted water coil in condenser (water cooled)

1. _____
2. _____
3. _____

G. Water restriction, or inlet water too hot in condenser (water cooled)

1. _____ 4. _____
2. _____ 5. _____
3. _____ 6. _____

H. Freon leak in evaporator (portable charge)

1. _____ 6. _____
2. _____ 7. _____
3. _____ 8. _____
4. _____ 9. _____
5. _____

I. Evaporator fins clogged with dust, lint, dirt or ice

1. _____ 5. _____
2. _____ 6. _____
3. _____ 7. _____
4. _____ 8. _____

SYMPTOMS

ss. long running cycle
tt. warm suction line
uu. freeze up (in metering device)
vv. overload trippled out
ww. high head pressure
xx. evaporator superheat too high
yy. suction warmer than normal
zz. cold liquid line
aaa. conditioned area too warm
bbb. high suction pressure
ccc. air volume low, or restricted
ddd. low suction pressure
eee. evaporator superheat too high
fff. lower than normal head pressure
ggg. liquid line too warm
hhh. compressor too warm
iii. conditioning area too warm
jjj. possible frost back on suction line
kkk. below normal head pressure

Simulate problems and have the student to repair. (operational systems)

Problem areas - (condensers & evaporators)

The instructor will use this format as a guideline to set up common problems encountered in the air conditioning field.

The instructor will place a fault in an operational system. Then, the student will diagnose and correct the problem in a craftsman like manner. The problems found by the student may be entered in the blank spaces below.

Condensers Air Cooled

A. Faults will be placed in an operational unit by the instructor. (air cooled condensers only)

   1. Symptoms found by the student may be recorded in the spaces provided below:

      1. _____

      2. _____

      3. _____

      4. _____

      5. _____

      6. _____

Condensers Water Cooled

A. Faults will be placed in an operational system as provided by the instructor.

   1. Symptoms found by the student may be recorded in the spaces provided below:

      1. _____

      2. _____

      3. _____

      4. _____

      5. _____

      6. _____

Evaporators-Direct Expansion

A. Faults will be placed in an operational system as provided by the instructor.

1. Symptoms found by the student may be recorded in the spaces provided below:

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

Evaporators-Indirect Expansion/Chilled Water

A. Faults will be placed in an operational system as provided by the instructor. (if available)

1. Sypmtoms found by the student may be recorded in the spaces provided below:

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

Common Symptoms in Coils

A. The student will follow the troubleshooting problem chart and write in the symptoms. The instructor will grade the answers.

1.	air passage through the condenser blocked. (approximately 1/4 to 1/3 blocked) (air cooled)	1. 2. 3. 4. 5. 6.
2.	freon leak in condenser. partical charge exist in system (air cooled)	1. 2. 3. 4. 5. 6. 7. 8. 9. 10.
3.	ambient temperature too high (above 95° F.) (air cooled)	1. 2. 3. 4. 5. 6.
4.	improper location which will restrict proper fresh air through the condenser and or, sun rays will be too hot (air cooled)	1. 2. 3. 4. 5. 6.

5. scale accumulation inside of water coil (water cooled condenser)	1. 2. 3. 4. 5. 6. 7. 8.
6. bursted water coil in condenser (water cooled)	1. 2. 3.
7. water restrictions or inlet water too hot in condenser (water cooled)	1. 2. 3. 4. 5. 6.
8. freon leak in evaporator (partical charge)	1. 2. 3. 4. 5. 6. 7. 8. 9.
9. Evaporator fins clogged with dust, lint, dirt or possible icing	1. 2. 3. 4. 5. 6. 7. 8.

Procedure for Cleaning Coils

The instructor will assign the student one or more condensers to be cleaned.

Condensers Air Cooled

A. Procedure for cleaning outside condenser coil: (unit must be off)

1. Dust, dirt, leaves and lint accumulation

   a. blow out with air pressure.
   b. Blow out with freon vapor (would be acceptable only if no air pressure is available).
   c. Clean fin surface with a steel brush.

2. Accumulation of grease or oil substance in the fin surface of the condenser:

   a. Use coil cleaner on the coil surface.
   b. Leave on the coil for approximately 30 minutes and wash off with pressurized water. (water hose will be sufficient)

3. Bent or mashed fins:

   a. Straighten the fins with a fin comb.
   b. If damage is too bad, replace the condenser.

Condensers Water Cooled

B. Procedure for cleaning a water cooled condenser

1. Accumulation of scale and algae in a condenser:

   a. Clean with condenser cleaner (as per manufacturer instructions).
   b. Flush with fresh water.
   c. Place a base solution in the water to eliminate strong acids. (as per manufacturer instructions)

2. Freon leak in water coil due to defect or freeze.

   a. Remove water cooled condenser.
   b. Repair leak (if applicable) or replace.
   c. Clean complete system out. (must be free of water)
   d. Re-install repaired or new condenser.
   e. Evacuate system and charge with freon.

Evaporators

The instructor will assign one or more evaporators to clean or repair.

C. Procedure for cleaning or repairing the evaporator

1. Accumulation of dust, dirt, and lint on the fin surface of the evaporator

   a. Clean with coil cleaner and flush with water pressure from a water hose.

   b. A steel brush may clean small amounts of accumulation from the coil surface.

2. Freon leak in the evaporator coil assembly

   a. Locate the leak.
   b. Remove coil assembly, if needed.
   c. Repair freon leak by soldering or installing new fittings.
   d. Replace and use correct steps to evacuate and charge the system with freon.

3. Chilled water evaporator coil

   a. Repair water leaks in coil.
   b. Remove if necessary.
   c. Possible priming of water pump at start up may exist.